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Explanatory Note

Illustrated articles are marked with an asterisk (*); book notices by a dagger (†). Inquiries by a double dagger (‡). The cross references condense the matter and assist the reader, but are not to be regarded as complete or conclusive. So, if there were a reference from "Boiler" to "Furnace" and if the searcher failed to find the required article under the latter word, he should look through the "Boiler" entries, or others that the topic might suggest, as he would have done had there been no cross reference. A reference from "oil" to "Lubricating" would apply equally to "Lubrication," "Lubricator," etc. Letters are indexed under title or subject, general articles under writer's name as well. Not all articles relating to a given topic necessarily appear under the same entries.

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POWER

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Drawn by C. H. Greene

A GOOD SUGGESTION, WELL EXPLAINED, ACCOMPLISHES MORE THAN A MULTITUDE OF COMPLAINTS

Power Plant of the Madison Avenue Building

By Thomas Wilson

SYNOPSIS—A small noncondensing, office-building plant carrying a lighting, elevator and power load and using exhaust steam in a vacuum system for heating.

In the uptown business center of New York City, a great many new office and loft buildings are being erected. Notwithstanding the advantages and the saving that might be effected with a private plant, most of these buildings are using Edison current. An exception is the Madison Avenue Building, located on the corner of Twenty-fifth St. and Madison Ave. The structure covers

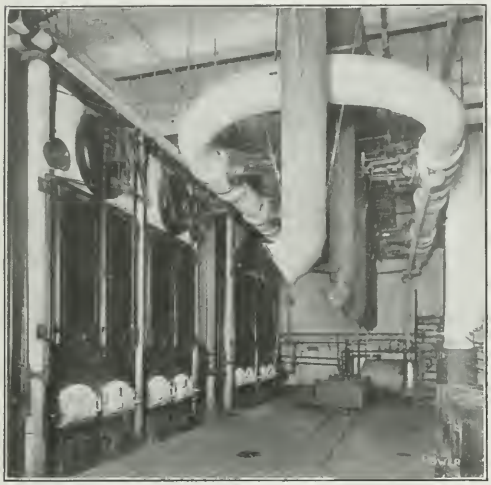

Fig. 1. Boiler Room

an area of 15,000 sq.ft., is 20 stories high, has a floor area of 300,000 sq.ft. and is to be used as a combination office and loft building.

The power plant, located in the sub-basement, 35 ft. below the street level, supplies the lighting, elevator service and heating. A good layout and good substantial equipment are the features of the plant.

The boiler room is equipped with four 200-hp. B. & W. water-tube boilers arranged two in a battery. The gases are discharged into a brick flue running over to the inside corner of the building and discharging through a steel stack 325 ft. high. The arrangement of the piping is shown in the plan view of the boiler and engine rooms. It will be noticed that a ring header is provided and equipped with valves so that any boiler can supply any unit in the engine room. A 6-in. U-header attached to the back connections of the boilers supplies the pumps and also live steam to the feed-water heater, which is of the "700 series" Cochrane type, having capacity to heat water for 750 boiler horsepower.

Feed water may be taken directly from the heater, the air-separating tank of the heating system, or directly from the city mains. Two 9 and 5 by 10-in. Worthington duplex end-packed plunger boiler-feed pumps of the pot-valve pattern are installed. There are also two 14 and 7¼ by 12-in. duplex fire pumps and the piping is so arranged that any one of the four pumps can supply the boilers, although the fire pumps can supply cold water only. Ordinarily they are used on the house service, and keep the tanks at the top of the building filled with water.

A Climax damper regulator is installed and is connected to a balanced damper in the main smoke flue. One Ellison draft gage serves the four boilers. A small brass pipe connects each flue with a manifold attached to the inlet of the gage. A valve in each pipe makes it possible to take a reading on each boiler separately, and the four readings in rapid succession.

No. 2 buckwheat coal is burned in the boilers. It is stored in coal pockets at the end of the boiler room, which receive their supply from the street and have a capacity of 450 tons. From the pockets the coal is conveyed to the boilers on an industrial coal car and hand fired directly into the furnaces. An electric-driven sidewalk lift of 1700 lb. capacity removes the ashes.

The plan view and the photographs show the layout of the engine room, which is equipped with four direct-conected generating units, made up of McIntosh & Seymour engines and General Electric three-wire, direct-current generators. There are two 12x15-in. piston-valve engines driving at 275 r.p.m., 75-kw. generators and two 15x32-in. four-valve engines running at 150 r.p.m. and connected to 150-kw. generators. Both engines have flywheel governors and heavy flywheels, weighing 2200 and 12,000 lb., respectively.

When the building is fully occupied one large and one small unit will be sufficient to handle the load. The other two units will be held in reserve and obviate the necessity of Edison breakdown current. It will be noticed that the units are arranged along the walls to give plenty of room in the center and to permit the operator to face the switchboard when throwing in a machine. The switchboard is equipped with the usual line of instruments. It

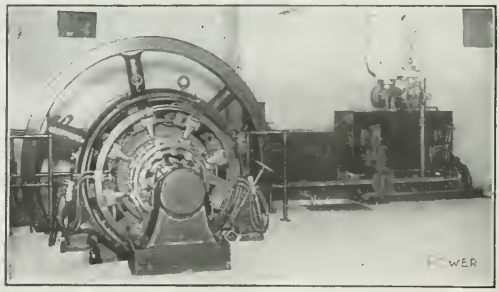

Fig. 2. One of the 150-Kw. Units

contains seven panels: four generator, one tie panel and two feeder panels, the lighting panel being at one end of the board and the power panel at the other. There are two sets of busbars, so that the lighting and power loads may be separated and may be supplied with energy from any one of the four units. When one unit is supplying the en-

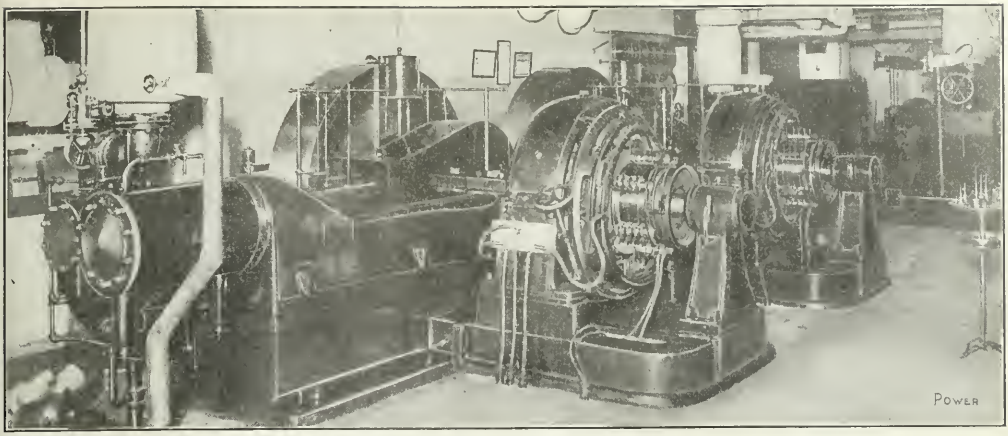

FIG. 3. THE TWO 75-KW. UNITS

tire load the busbars are thrown together by means of the tie panel At the time of the writer's visit only one machine was running and there appeared to be no difficulty in operating the lights and elevators from the same supply.

Exhaust steam is used for the heating with provision for live steam when necessary. The connections of the exhaust steam piping are shown in the accompanying plan. From the last unit to the heater, the exhaust pipe is 14 in. in diameter, and its continuation to the riser supplying the heating system or to the atmospheric exhaust is 12 in. in diameter. The Dunham vacuum system heats the building. There are 47,000 sq.ft. of radiating surface and a typical radiator connection is shown in Fig.

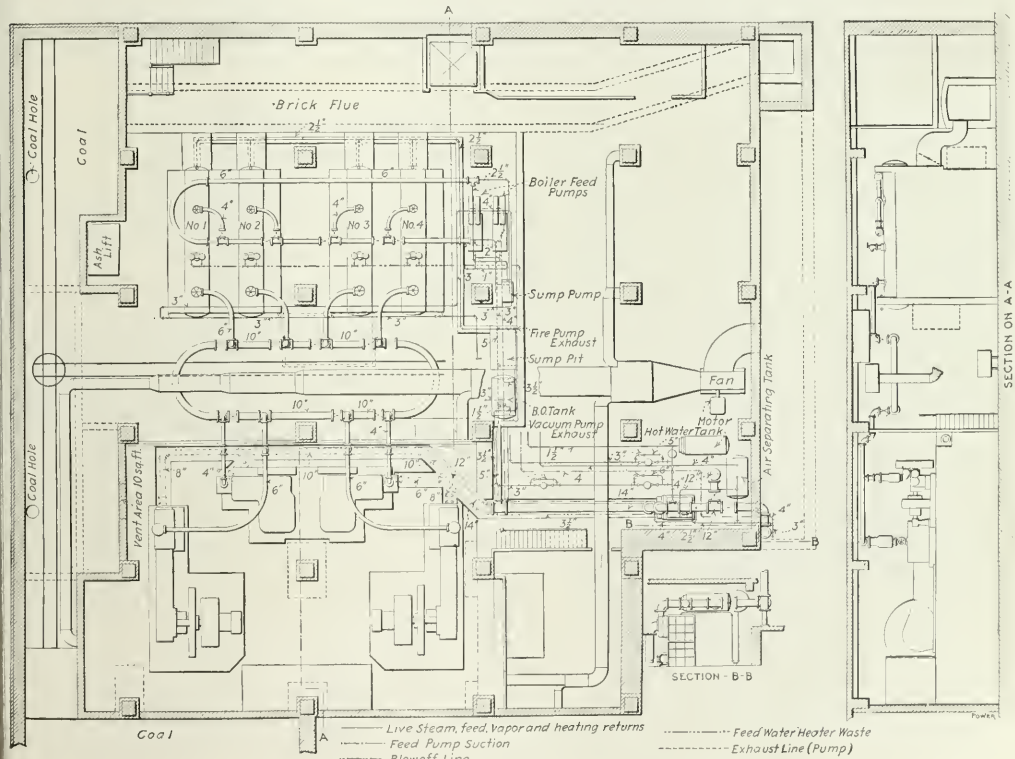

FIG. 4. GENERAL PLAN, SHOWING LAYOUT OF PIPING

6. On the return end of the radiators 1½-in. Dunham valves have been provided. From here the return line is 3/4 in. in diameter and the main return is 1½ in. This is connected through a gate valve and suction strainer to the suction inlets of the two vacuum pumps, which are 8

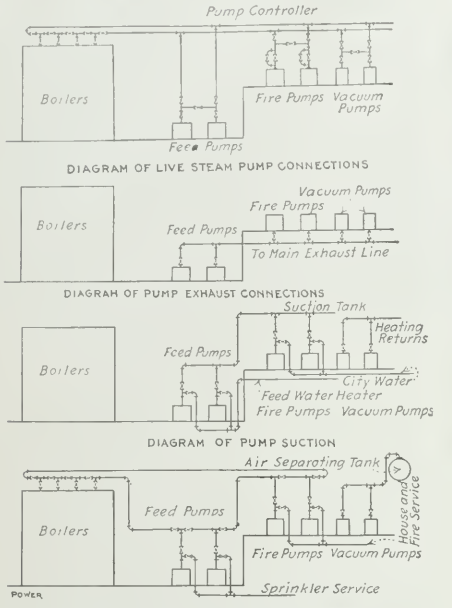

Fig. 5. Steam and Water Connections of Pumps

and 12 by 12-in. A vacuum of about 10 in. is carried at the pumps. The discharge of each pump is carried through gate and check valves and connected into a common line which in turn discharges into the air-separating tank. The steam lines to the pumps are connected through vacuum governors provided with bypasses.

A total of 13 elevators, seven passenger and six freight, serve the building. Five of the passenger elevators are operated by 35-hp. motors at a speed of 700 ft. per min. The other two, which run from the basement to the fifth floor, are served by 25-hp. motors at a speed of 500 ft. per min. The freight elevators operate at a speed of 400 ft. per min. and are all served by 35-hp. motors. The entire elevator equipment was supplied by the A. B. See Co.

The results obtained in the acceptance test, made by Clark, MacMullen & Riley, who were the engineers for the building, may be of interest. The determination of

Fig. 6. Typical Radiator Connection

the water rate was limited to one engine of each type, as the units were exact duplicates.

As the plant is arranged so that any two units may be run independently of each other, the house load during the test was carried by one engine operated from one of the boilers, while the engine under test was operated from another boiler, with a separate feed pump. This permitted the exact amount of water used by this boiler to be measured by the usual two-barrel method. The load consisted of resistance coils under running water and was

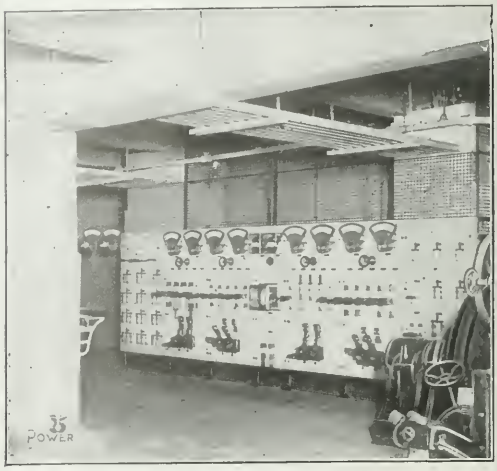

Fig. 7. Seven-Panel Switchboard

maintained nearly constant throughout both tests. A rate of 22.5 lb. of dry steam per indicated horsepower-hour was obtained on the larger engine while the smaller engine required 33.6 lb. of steam.

Standard Smokeless Furnace

An arrangement of boiler furnace and auxiliary heating device put out by the Standard Fuel Reduction Co., 55 Liberty St., New York City, is illustrated herewith. The maker states that this furnace when installed, will not only eliminate smoke within the law, but will increase the efficiency of the boiler.

As shown in the sketches *A* and *B*, Fig. 1, one tube of the return-tubular boiler is removed and a pipe connection made with the boiler head. This pipe is connected to the end of a larger pipe, which extends across the furnace at a height about level with the bridgewall. The opposite end of the cross pipe is connected to the rear boiler-head tube opening. An extension of the horizontal pipe passes out through the rear boiler brick wall.

Just above the cross-circulating pipe is a second, but smaller pipe, in which a series of nozzles are arranged opening toward the rear of the boiler. This nozzle pipe is protected from direct contact with the furnace flames. One end of the pipe is plugged and the other is attached to a vacuum globe, as shown in sketch *A*. This globe holds a vertical air pipe. At the bottom of the vacuum globe a connection is made with a steam pipe connecting with the steam space of the boiler. The inner connection ends with a steam nozzle so placed that the outlet is central with the center of the horizontal nozzle pipe and discharging into it longitudinally, as shown at *C*.

When steam is turned into the steam nozzle a partial vacuum is created in the vacuum globe and air is drawn

in through the vertical pipe, which extends above the top of the boiler setting. This mixture of steam and air escapes through the several nozzles and mingling with the escaping gases in the combustion chamber, produces smokeless combustion.

The volume of air entering the vacuum globe is controlled by the amount and pressure of steam escaping through the steam nozzle.

As a further aid to combustion the chamber at the rear of the bridgewall is filled in and lined with brick. The curvature of the bridgewall forces the gases from the furnace to pass between the horizontal water pipe and the bridgewall, so that the mixture of steam and air is enabled to mingle with the gases in the combustion chamber.

In Fig. 2 is shown the arrangement of steam and air jets when applied to a water-tube boiler. The baffle wall above the bottom row of bricks extends from the front and rear ends of the furnace with an opening in the center through which the flames pass to the first pass of the boiler in the direction of the arrows.

This furnace is put in under a boiler on 30 days' free trial basis by the manufacturers in order to prove their guarantee.

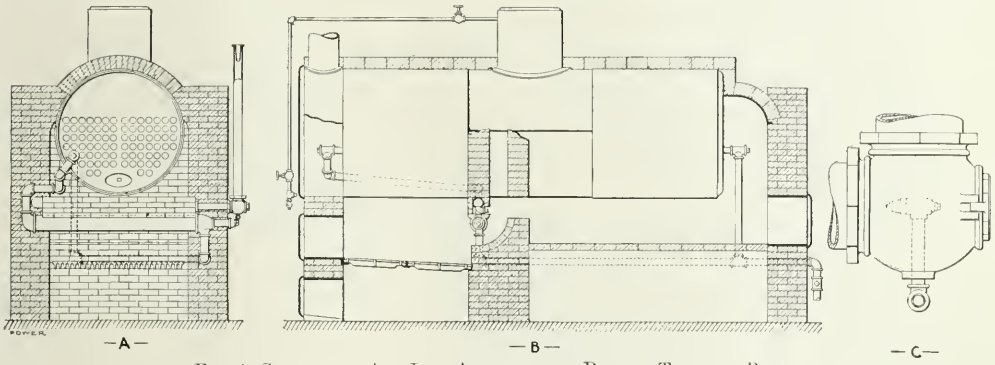

FIG. 1. STEAM AND AIR JETS APPLIED TO A RETURN-TUBULAR BOILER

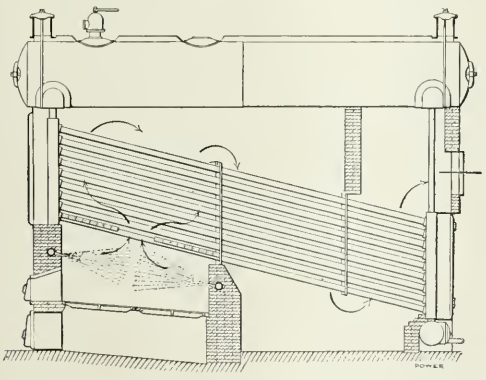

FIG. 2. AIR NOZZLES APPLIED TO FURNACE OF WATER-TUBE BOILER

A Large Air Compressor

Zeitschrift des Vereines deutscher Ingenieure for Apr. 19, of the current year, says that in common with all engines used in the mining and blast-furnace industries the present-day makes increased demand on the air compressor, and illustrates and reviews the more salient feature of an unusually large example of such latter equipment.

Up to about 10 years ago compressors with an hourly output of 350,000 to 400,000 cu.ft. were of the largest in use. Today almost double that duty has been reached without a material increase of floor space. Several of these large machines have been furnished by Rud. Meyer, of Mulheim on the Ruhr, for the Rand mines in the Transvaal country. They have the following dimensions:

Diameter of steam cylinders	31x62 in
Diameter of air cylinders	54x33 in
Common stroke	50 in
Speed	65 to 72 r.p.m
Free air intake per hr.	565,000 to 644,500 cu.ft
Total weight	176 tons
Diameter of flywheel	21 8 ft.
Face of flywheel	26 in.
Total floor space	1560 sq.ft.
Normal duty	1700 to 1750 hp.
Widths of air-cylinder pistons	52, 75 and 44 in.
Diameters of air nozzles	
High-pressure side	17 in.
Low-pressure side	28 in.

The steam cylinders have the Doerfel positive valve-gear; the air cylinders Meyer disk valves for high rotative speeds. The steam end is run condensing and its cylinders are jacketed with live steam. The machine is unprovided with tail rods and guides, notwithstanding the long stroke rendered unnecessary by the construction of the air pistons.

The acceptance test showed the following results: Mechanical efficiency, 89.25 per cent.; volumetric efficiency, 98.7 per cent.; steam consumption, 11.28 lb. per i.hp.-hr. at a pressure of 172 lb., a temperature of 482 deg. F. and a vacuum of 25 in.; air temperature at a pressure of 89.5 lb. behind the low-pressure cylinder, 203 deg. F.; behind the high-pressure cylinder, 196 deg.; showing an advantageous working of the intercooler in as much as temperatures of 212 to 230 deg. are generally counted on.

Electrically operated reciprocating compressors have thus far not attained such service; the largest of these delivering from 318,000 to something over 400,000 cu.ft. per hr. at speeds of 104 to 125 r.p.m.

Mixed-Pressure Steam Turbine*

By L. G. Hanna.

SYNOPSIS—The cardinal advantages of the mixed-pressure steam turbine are presented, showing how the exhaust steam from a reciprocating engine is utilized and how live steam can be used to operate the unit when no exhaust steam is available.

Assuming a plant in which 2000 boiler horsepower is generated, there must be 60,000 lb. of steam, which, after being used in an engine, escapes as exhaust steam. If this exhaust steam were utilized in an exhaust-steam turbine where every 60 lb. of exhaust steam would produce 1 kilowatt, 1000 kw. would be generated, which costs nothing.

Exhaust steam, however, is not always without value to a manufacturer, and in many cases is utilized in processes of manufacture wherein a certain fixed temperature is to be maintained.

In almost every plant, exhaust steam from various sources is utilized in a feed-water heater, a point which should be carefully considered before assuming that all exhaust steam is pure gain. For instance, in the assumed 2000-hp. plant, 60,000 lb. of water is converted into steam every hour. Therefore, 60,000 lb. of feed water at a temperature of, say, 70 deg., should be raised to a temperature of, about 200 deg.; with a heater of roughly 70 per cent. efficiency, approximately 11,400 lb. of steam would be required, leaving 48,600 lb. of steam for other work.

Assuming that the steam has been used in various small steam engines, pumps, etc., and that 30 per cent. has been condensed, there would remain but about 34,000 lb. of steam available for the turbine, etc., of which 20,000 lb. may be utilized in processes of manufacture and which is consequently not available for power generation. The remaining 14,000 lb. of steam, if utilized in an exhaust-steam turbine, would be sufficient to generate 335 kw., which might be considered as clear gain, exclusive of interest and depreciation on the investment, oil and maintenance. These items should not represent more than 7 per cent. on $11,000 or $1320, plus, say, $600 for oil and maintenance, which would be $1920, say, $2000 per year. Assuming a plant to run but 10 hr. per working day at full load, that means 3000 hr. a year, and as 335 kw. is generating from exhaust steam there would be generated 1,005,000 kw.-hr. per year, at a total cost, including interest, depreciation and maintenance, etc., of $2000 or less than two-tenths of a cent per kilowatt-hour. This example in generalities, is a typical condition, and indicates what is to be looked for in an exhaust-steam turbine proposition.

[Dealing with the theory of the exhaust-steam turbine, the speaker pointed out that heat, which in steam is the real source of power, can be converted into mechanical work only by the expansion of the steam; that theoretically the moisture in the exhaust from an engine expanding from 150 lb. gage to atmospheric pressure is about 15 per cent., but on account of reëvaporation, which takes place in the engine cylinders during the expansion part of the stroke, this will, in practice, be found to be nearer 10 per cent., and approximately as much heat is available for doing work from atmosphere to 28 in. of vacuum as when expanding from 150 lb. gage to atmospheric pressure.—Editor.]

Economy of Low-Pressure Turbines

An exhaust-steam turbine, designed to properly expand the steam, will turn more of the heat into work when working on this low-pressure range than a high-pressure turbine or an engine when working on high pressure range, expanding from 150 lb. gage to atmospheric pressure, because the frictional or windage loss of the exhaust turbine is very small since the rotors run in a vacuum.

Tests have shown there is a reduction of 8 per cent. in the steam consumption of a turbine when it is exhausting into a 28-in. vacuum over the steam consumption with a 26-in. vacuum. In other words, for a given amount of exhaust steam, 8 per cent. more available work can be secured by carrying a 28-in. vacuum than can be secured by carrying a 26-in. vacuum.

In the long run a 28-in. vacuum is advisable, but in order to maintain it nearly twice as much water must be circulated through the condenser as would be required to maintain a 26-in. vacuum, and at the expense of a certain amount of power to drive the circulating pump: it means an increase in the cost in the condensing apparatus of approximately 40 per cent. It may be that these items, when figured in dollars and cents and when depreciation is taken into account, would not show an economy commensurate with the investment, in which case it is well to keep the first cost low by using a condenser capable of maintaining a 26-in. vacuum.

In general, the steam economy of a simple engine and an exhaust-steam turbine operating together, is always an improvement over that which would be obtained by compounding the simple engine. The plant capacity is increased from 50 to 100 per cent. by exhausting through an exhaust turbine to a condenser on a noncondensing engine; the increased capacity obtained by adding the turbine to a condensing outfit, is from one and one-half to three times that which could be secured from the condenser alone.

Like the high-pressure turbine, the low-pressure turbine operates at nearly uniform efficiency over a wide load variation while the economy of a reciprocating engine is not good when the latter is under- or overloaded. Therefore, the combination of the engine and the low-pressure turbine will give more uniform economy at all loads than will the engine alone.

When more power is required the plant owner has three alternatives in securing it. First, he may install a larger or additional engine, which is an expensive proposition, requiring additional boiler capacity, perhaps involving expense for enlarging the buildings, and increasing labor and upkeep costs materially.

Second, more power may be secured by running the old engine condensing, but no engine either simple or compound, even when operating at the best economical point of cutoff and otherwise under the best conditions

*Excerpt from a lecture delivered before Melville Council, No. 9, Universal Craftsmen, Friday, May 16.

can deliver over 20 to 25 per cent. more power than when running noncondensing.

The third method is that of changing the engine to run condensing, and utilize the additional range of pressure drop to drive an exhaust-steam turbine, making is possible not only to almost double the amount of power previously secured from the engine, but doing it without increasing the duty on the engine and without using any more steam than before.

The initial cost of the turbine and condenser per horsepower is less than for additional boiler and engine capacity. The turbine and condenser fit into a very small space, and as the combination takes the same quantity of steam as would the engine alone and under the same conditions as before, there is not an additional penny of expenditure necessary for boilers, chimneys, draft, coal-handling apparatus, building and steam piping. The turbine and condenser, or turbine alone in a condensing plant, can be cut into the exhaust line without interfering in any way with the engine and usually without altering the layout of the plant.

The installation of the turbine hardly affects plant-operating costs, as the turbine seldom requires other attention than occasional lubrication and repacking of stuffing-boxes. The oiler who has previously been taking care of the engine can look after the turbine without any serious drain on his time.

An engine that has previously been running noncondensing continues to exhaust at about the same pressure and carries the same load after the turbine is cut into the exhaust line. A condensing engine can be adjusted to exhaust at atmospheric pressure or thereabout and will be relieved of that part of the load assumed between atmospheric pressure and the vacuum while the turbine is being operated. The water of condensation will be discharged from the condenser at a temperature within two or three degrees of the theoretical and can be utilized in the usual ways.

Other Advantages

An exhaust-steam turbine develops power largely from energy which, with a reciprocating noncondensing engine, must be wasted or at best used in heating systems or for preheating feed water. The amount of mechanical work obtainable from a reciprocating engine is limited by the number of expansions possible in its cylinder. Even when using steam at the earliest point of cutoff only about 20 expansions are possible in a single-cylinder engine, while compounding will not permit of more than 30 expansions, and even under the most favorable conditions when running condensing, the engine does not exhaust to the condenser at less than 5 lb. absolute pressure or 20 in. of vacuum.

The turbine, on the other hand, is capable of utilizing very nearly the complete range of expansion and thus develops the extra power. The turbine, being specially adapted to handle the larger volume of steam after partial expansion in the engine cylinder and permitting the further expansion through the lower pressures, easily and without exceeding moderate dimensions permits the further constant change of heat into work until the vacuum of the condenser is reached. The mechanical loss in the turbine is largely due to windage. The mechanical friction in the turbine is practically nothing compared to that within the reciprocating engine, and as the exhaust port is larger than the steam passages, the full value of the condenser pressure is available. The maximum amount of work from the steam is obtainable only where the engine is augmented by the turbine.

Exhaust-steam turbines will convert about 50 per cent. of the available heat below atmospheric pressure into work, so the addition of the turbine to the engine, and the relieving of the latter of the work done below atmospheric pressure, can safely be said to offer a power increase of not less than twice that which would be secured by merely changing a noncondensing engine to run condensing.

Operating Details

In most cases the ordinary exhaust-steam turbine is on an electrical load, the fluctuations of which are entirely remote and in no ways simultaneous or similar to those which occur to the mechanical load from which the turbine derives its supply of exhaust steam.

One way to handle this condition is to connect in the electrical load of the turbine, a synchronous motor, belted to a line shaft, which is part of the mechanical load. In the event of the normal electrical load being light, and the mechanical load heavy, the motor acts as a motor, transferring power from the turbine to the line shaft, reducing the steam in the mechanical system and consequently the supply of exhaust to the turbine, thus affecting the balance.

In case the electrical load is heavy and the supply of exhaust steam inadequate, then the motor acts as a generator parallelled on the electrical system, thus increasing the demand on the mechanical system and reducing the demand on the turbine in the electrical system.

Another method which is useful in cases of momentary interruptions of adequate steam supply is the regenerator in which the heat from excess steam is stored to be reimparted when the supply diminishes. This scheme calls for a cumbersome and expensive equipment and applies only in very few instances.

In the mixed-pressure turbine, any deficit of exhaust steam is made up from a high-pressure line from which the high steam-pressure supply is automatically cut off when the supply of exhaust steam again becomes adequate. In the case of wide fluctuations both in the load on the turbine and on the mechanical system there will be times when exhaust steam escapes to the atmosphere, through the relief valve, while at other times there may be required a considerable amount of live steam to make up the deficit.

To offset these drawbacks, are the following considerations in favor of the mixed-pressure arrangement. Its low cost over straight low pressure; its simplicity, and consequently its dependability; the fact that in nearly every case mixed-pressure turbines may be so designed as to strike a happy medium between the minimum and maximum conditions; its extreme flexibility to all possible load conditions between one-quarter load and 50 per cent. overload. Perhaps most important of all, to the small isolated plant, is the fact that a mixed-pressure turbine may be utilized to develop its full-rated capacity on high-pressure steam in the case of a serious interruption of, or breakdown in, the machine furnishing the supply of exhaust steam.

Air in Surface Condensation*

SYNOPSIS—Some results of tests of condensing apparatus to determine the amount of air leakage in standard condensers and the effect of such leakage on the working of the apparatus. Curves are reproduced to show the falling off in vacuum, due to air leakage, and the effect of load on such leakage.

In view of the lack of knowledge of this subject, the author determined to investigate:

a The amounts of air contained in feed water and those entering the condenser through the prime mover.

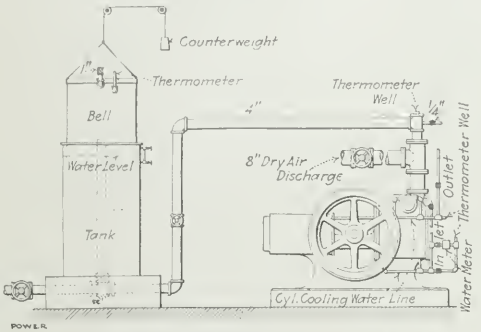

FIG. 1. GASOMETER FOR MEASURING AIR LEAKAGE INTO CONDENSER

b The amounts of air removed from the condenser by means of the air pump.

c The effect of known quantities of air on the action of a surface condenser of commercial size.

The author's investigations were made at the Waterside No. 2 station of the New York Edison Co., and the water samples were taken both from the suction and discharge sides of the feed pump. The average temperature of the feed water during the tests, after having passed the heater, was about 190 deg. F. It was thought possible that there might be air bubbles mechanically entrained in the water, besides the amount of air in solution. To determine the amount of this entrained air, samples of the water were allowed to flow through a measuring apparatus. The water entered through a tube and passed to the top of a measuring cylinder where the air separated and was collected at the top of the cylinder; the water flowed out of the cylinder through a tube into a glass demijohn where it was measured. These tests were started with the apparatus entirely filled with water. The air collected was measured at atmospheric pressure by means of a pressure-regulating cylinder. The temperature of the air was determined by a theromometer in the measuring cylinder.

Test results showed that Croton water gives off most of its dissolved air in passing through the open heaters, the amount of air occluded in the feed water (0.931 per cent.) being comparatively small. At 81 deg. F. and 2 in. of mercury absolute pressure when saturated with water vapor, this amount of air would occupy between 20 and 30 per cent. of the volume of the condensed steam. The fact was established that very little air came into the condenser from the feed water.

Having obtained the portions of air which enter the prime mover along with the steam, the next object of investigation was to determine the amount of air abstracted from the condenser by the air pump. Here, again, there were no precedents; but it was determined to catch the air over water in a gasometer. For this purpose the discharge pipe of the air pump was piped to a gasometer bell located in the basement in the vicinity of the air pump. The arrangement of this outfit is shown in Fig. 1.

After the air pump had been running long enough to make sure that the conditions were constant, the valve was opened and the discharge from the air pump allowed to enter the bell, permitting it to rise. The time required to fill the bell was noted with a stop watch and from these data the amount of air delivered was calculated. The air in the bell was brought to atmospheric pressure and temperature before the final readings were taken.

Other tests were made with the pump shut off from the condenser to determine the air leakage in the pump itself and also with the suction piping blanked off at the condenser to determine the pipe leakage.

In the experimental apparatus used to obtain the data for the paper on "The Transmission of Heat in Surface Condensation,"[1] it was impossible to detect any difference of temperature due to the segregation of air in the various parts of the single-tube condenser. On the large condensers on which these air tests were made, such a difference of pressure and temperature does exist, the difference of pressure being quite strongly marked. The curves for a number of these condensers, showing the increase in drop with the increase in amount of steam consumption, are illustrated in Fig. 2.

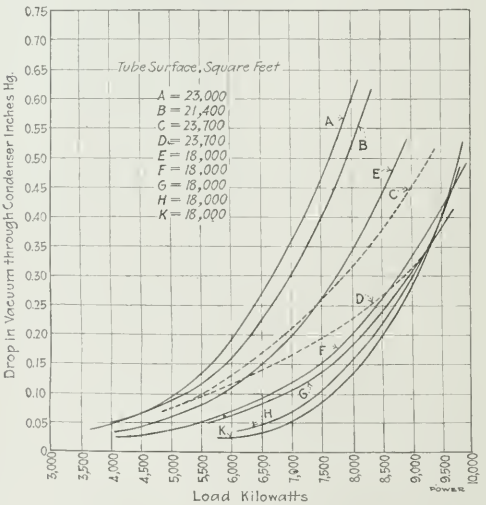

FIG. 2. CURVES SHOWING RELATION BETWEEN LOAD AND DROP IN VACUUM THROUGH CONDENSER

A number of experiments were made to find if this

*Excerpts from a paper by Geo. A. Orrok and from discussions of the paper, Journal of the American Society of Mechanical Engineers, November, 1912, and February, 1913.

[1]Trans. Am. Soc. M. E., Vol. 32, p. 1139.

drop was continuous through the tube surface or whether there were restrictions concentrating the drop in one or more places, and a number of experiments were made to reduce the amount of drop by taking out tubes, thus opening channels into the body of the tube surface. The results here were apparently negative.

To ascertain the effect of known quantities of air on the vacuum, suitable orifices of various sizes were made at the top of the condenser so that the introduced air might mix with the incoming steam. The orifices were of the ordinary circular form through thin plates and the amounts of air entering the condenser were checked up by the air delivered into the air bell from the air pump. These results are shown in Fig. 3.

The tests in each case were made at constant load, which was considerably below the capacity of the condenser.

Four sets of tests were run to determine the effect of load on air leakage, two on machines which were in bad condition and two on comparatively tight machines. The results are shown in Fig. 4. It should be noted that in every case the air leakage is less at the higher loads.

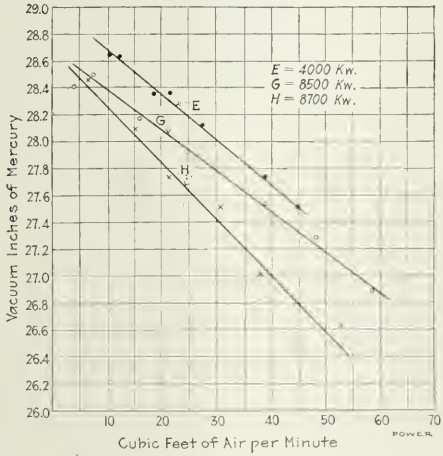

Fig. 3. Curves Showing Effect of Air Leakage at Constant Load

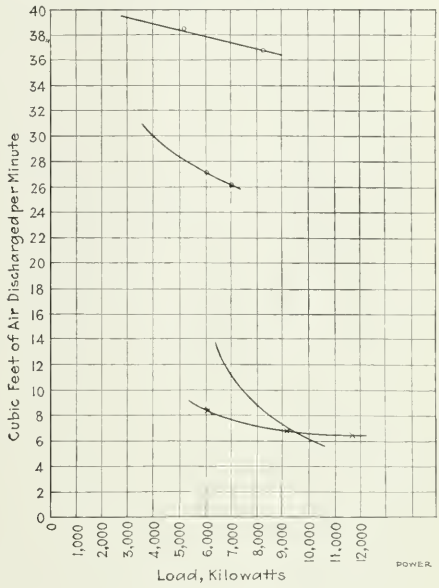

Fig. 4. Curves Showing Effect of Load on Air Leakage

Where open heaters are used, very little air is carried to the prime mover with the steam. The volume of this air at atmospheric pressure and temperature will probably not exceed 1 per cent. of the volume of the feed water. As the whole system is under pressure from the pump nearly to the final stage of the turbine, no air leakage can take place up to that point.

The air discharged by the dry-air pump at atmospheric pressure and temperature from units between 5000 and 20,000 kw. in size varies from 1 cu.ft. per min., when the units are in the best condition, to 15 or 20 cu.ft., where ordinary leakage is present, and to 30 or perhaps 40 or 50 cu.ft., where the units are in a very bad condition.

Most of this leakage comes into the condenser and exhaust passages through minute leaks in the cast-iron shells, gaskets and expansion joints. It is exceedingly difficult to detect these leaks with a candle flame, but most of them may be detected by filling the condenser with warm water under a slight head. That portion of the leakage occurring in the dry-air pump and piping may be detected by the shutoff test on the pump. The volume of this leakage is larger than is generally supposed and is much larger when the pump is warm.

The drop in vacuum through condensers of standard design is larger than it should be and a design which more freely admits the steam to the tube surface should give better results. The opening of the channels into the surface will not always improve conditions. The results indicate that wide, shallow condensers should give better results; although, in at least two instances, deep, narrow condensers gave good results.

The falling off of vacuum with increased air leakage is considerable and the work necessary to maintain tight condensers more than pays for itself.

During these experiments, in which four different kinds of dry-air pumps were investigated, it became evident that the volumetric efficiency of a pump working between ¼ and 15 lb. absolute is very poor indeed. The difficulties of keeping valves, pistons, glands and packing tight against such a tenuous fluid as air at vacuum pressures are of much greater moment than is usually believed. It is hoped that some of the types of kinetic air pumps will reduce considerably air leakings at these joints.

Considerable difficulty was experienced in securing vacuum temperatures during these experiments and most of the work has been repeated a number of times where such temperatures are essential. It has been impossible, up to the present time, to secure readings which were entirely consistent and the work along this line will be carried on until the cause of the discrepancy is ascertained and correct figures obtained.

In the discussion on Mr. Orrok's paper, the following interesting information was brought out:

Some years ago it was noted in a barometric-condenser installation that air leakage was apparently taking place under high vacuum through the cast-iron pipes themselves, as the vacuum could be improved by painting the pipes with asphaltum. The piping was well made and apparently free from blow-holes.

Considerable trouble was experienced in preventing air leaks through the gaskets under the end heads, especially after the pipe had been heated up. Hence, the bolts and gaskets at the joints should receive particular attention when air leaks are suspected.

The tests were not conclusive with regard to the effectiveness of the different paints in reducing vacuum losses. Paints with asphaltum base were very effective in preventing leaks at low temperatures, but softened and tended to drip at temperatures from 210 to 225 deg. F., which would occur should the vacuum fail. One paint, said to be a linseed-oil preparation with a peroxide of iron base, formed a close impervious film on the piping and showed no deterioration from the temperature change within the range of tests.

The theory advanced by several writers that seems to

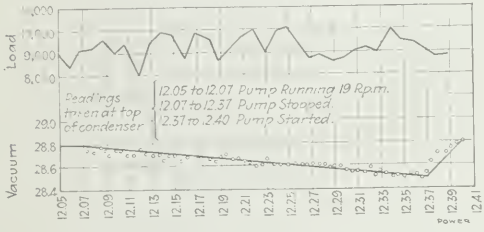

FIG. 5. SHOWING GRADUAL DROP IN VACUUM AFTER STOPPING AIR PUMP

account in the best manner for the fall in vacuum, with increased quantities of air, is as follows: As steam condenses on the tube surface, the air is left behind and the medium surrounding the tube then contains proportionately much greater quantities of air than the steam entering the condenser. The pressure of this air lowers the partial pressure of the steam and, consequently, its temperature. Hence, there is a less temperature difference between the tubes and the steam and, therefore, the rate of condensation is lowered. This theory emphasizes the necessity of providing in the design for a rapid sweeping away of the air to the air pump as fast as the steam condenses.

In connection with Mr. Orrok's figures as to the amount of air entering through the prime mover, the following data, showing the amount of air entering through turbine seals, may be of interest. They were obtained by the Wheeler Condenser & Engineering Co., with their portable testing gasometer, similar in design to Mr. Orrok's, and may serve to emphasize the importance of maintaining proper pressure on the steam seals.

In the test in question, which was made on a jet condenser, serving a 2000-kw. turbine, at no load and with no steam on the turbine seals, a total of 86 cu.ft. of free air per min. entered the condenser, a corrected vacuum of 26.6 in. being maintained under this condition. With an ordinary amount of steam on the seals and a mercury manometer registering a slight pressure, 64 cu.ft. per min. entered the condenser at no load and the vacuum was raised to 28.5 in. On a similar unit of like size, approximately the same figures were obtained: With a load of 1650 kw. on the turbine, and no steam on the seals, 91 cu.ft. of free air per min. entered the condenser, the vacuum dropping to 25.9 in. corrected. With normal steam pressure on the seals, the amount of air was reduced to 56 cu.ft. and the vacuum increased to 28.1 in. A further increase of pressure on the seal was found to have no appreciable effect.

It is to be hoped that the time will come when every power station will be equipped with a gasometer or a similar device for testing for air leaks. As it is now, the condenser manufacturer must design his air pumps to handle not only the air which he knows by experience will enter with the steam or by infiltration; in addition, he must assume the responsibility for turbine seals, for careless pipe joints and for slipshod maintenance. That is, he must proportion his air pumps to handle far more air than should be necessary and the net result is a considerable overall loss. It is no exaggeration to say that probably over 75 per cent. of the vacuum troubles in condensers today may be traced directly to an abnormal air leakage. It is to be hoped that further investigations, similar to Mr. Orrok's, will be made, in an attempt to determine the air displacement necessary, say, per 1000 lb. of steam under standard conditions.

The benefit of operating upon a closed system and cutting out the air as much as possible is unquestionable; Fig. 5 shows the effect of stopping the vacuum pump of one of the Boston Elevated units. It was realized from past experience that the vacuum upon the system would not suffer seriously even if the dry-vacuum pump were stopped temporarily, and James D. Andrews, chief engineer of the plant, kindly consented to stop the vacuum pump on one of the units for one-half hour, making one-half-minute observations of the fall in vacuum. This unit was developing 9000 to 10,000 kw. and carrying a vacuum equivalent to 1.03 in. absolute pressure when the pump was shut down. In one-half hour the vacuum had fallen only 0.32 in., or to 1.35 in. absolute. This curve is almost a straight line between the two points showing that the drop in vacuum is substantially uniform.

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Indian River (Canada) Developments

The Halifax Power Co. is planning to develop two sites on the Indian River, 18 miles west of Halifax. The upper station will include two units of 1200 kv.-a. each. One operates on 90 ft. head from the Indian River watershed and the other on 160 ft. head from the North-East River watershed; the latter water is carried over to the Indian River by means of a long pipe line. The lower station will include two units of 1200 kv.-a. operating on 90 ft. head; in this station the step-up transformers and high-tension gear will be placed.

These developments will render 5600 hp. available in Halifax, which will be carried over a duplicate transmission line by two separate routes. Transmission will be at 33,000 volts. It is the intention of the company to sell this power for lighting and industrial requirements in Halifax. Plans are well under way for the upper development, one transmission line and receiving station, and it is expected that this portion of the work will be proceeded with immediately.

Bristol Recording Differential-Pressure Gages

A new line of recording differential-pressure gages has recently been developed by the Bristol Co., Waterbury, Conn. Some of these recorders have been in successful service continuously for four years, and the design and construction of the instruments now being placed on the

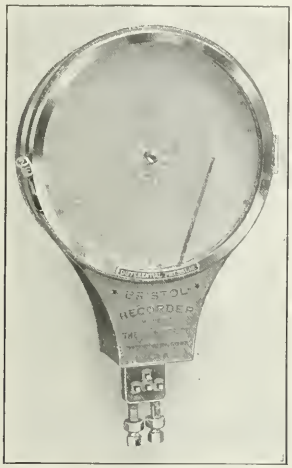


Fig 1. Bristol Recording Differential-Pressure Gage

market is based on results obtained in actual service during this time. Fig. 1 is an exterior view.

These gages are designed for use in connection with venturi meters, pitot tubes, orifices, combinations of orifices and pitot tubes, etc., and thereby to record velocities and volumes of air, gas, steam, water and other liquids flowing through mains and pipes. These recorders may also be used to advantage for recording differences and variations of liquid level in steam boilers, pressure tanks, filter beds, process kettles, etc.

The fundamental principle employed in the construction of this differential-pressure gage is that one pressure is applied to the inside of the operating tube while the other is applied to the outside of the same pressure tube within a closed casing. To record the movement of the pressure tube it becomes necessary to transmit its motion to the outside of the pressure-tube casing. As the differential pressure to be recorded is usually small, as compared with the static pressure, the operative force is correspondingly small. As it is impractical to use a stuffing-box around a shaft passing through a pressure casing, on account of the friction, a frictionless sealing device is employed.

In Fig. 2 is shown a hollow, helical, pressure tube. The two pressures, the difference of which is to be recorded, are applied, one to the interior of this tube through the lower right-hand pipe, the other to the exterior through the other pipe. The pressure tube is entirely inclosed in the pressure-tight casing. The movement of the pressure tube will be in proportion to the difference between these two pressures, and this motion is transmitted to the recording pen arm, outside of the pressure casing, by a small shaft through a long tubular sleeve. The capillary action of the oil or liquid between the sleeve and shaft makes this joint both frictionless and pressure tight.

In Fig. 3, the pressure-tight casing incloses the diaphragm pressure tube. Here, also, one pressure communicates with the interior and the other with the exterior of the tube, and its motion is transmitted by a rotating shaft through a sleeve to the recording pen arm. The length of this sleeve is many times the diameter of the shaft passing through it, unlike an ordinary bearing.

This device permits of recording extremely small differences between the pressure existing inside and outside of the pressure tube. The frictionless sealing sleeve through which the pen-arm shaft passes does not produce appreciable resistance to the rotation of the shaft, and capillary attraction and adhesion prevent leakage of even high pressures from the pressure casing.

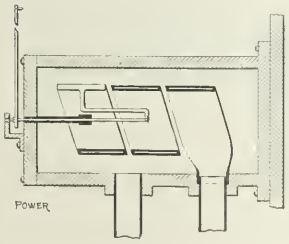


Fig. 2. Interior of Helical Pressure Tube

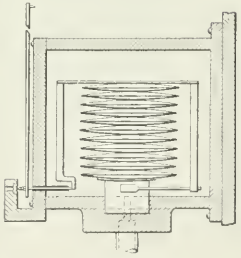


Fig. 3. Interior of Diaphragm Pressure Tube

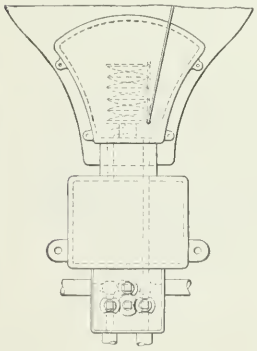


Fig. 4. Connections for Diaphragm-Type Gage

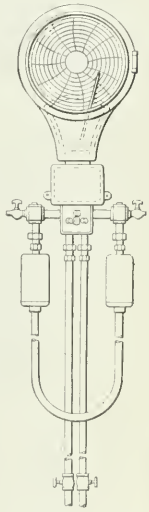


Fig. 5. Safety Device

In Fig. 4 a diaphragm tube is shown in the pressure chamber of the casing directly connected to one end of the rotating shaft passing through the pressure seal, and

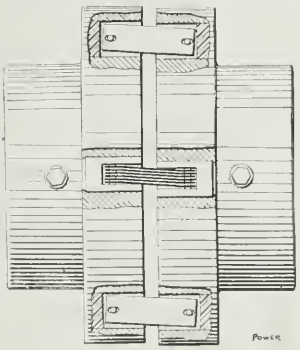
having its other end directly connected to the recording pen arm.

This illustration also shows a set of interlocking valves, which constitute a device for adapting recording differential-pressure gages to practical operating conditions. The upper cross-valve is shown in an open position connecting the two pressure pipes. The two lower valves in the pressure pipes are shown closed. Both of these valves can be opened, allowing the static pressure from either pipe to be applied simultaneously to the inside and the outside of the pressure tube of the actuating mechanism. The lower central or interlocking member can then be turned through an angle of 90 deg., making it possible to close the upper valve, which completes the connections so that the instrument will record the difference between the two pressures.

In Fig. 5 is shown a patented safety device consisting of a U-shaped tube, partly filled with a liquid such as mercury or water. This tube has enlarged chambers, having sufficient volume to accommodate the quantity of liquid contained in the tube. The length of the U-tube varies with the range of the gage so that the greatest possible head of the liquid contained in the U-tube corresponds with the total range of differential pressure the gage is designed to record. Should the full static pressure accidentally be admitted to either side of the differential gage, the liquid contained in the safety U-tube would instantly be forced up into one of the enlargements, thus allowing the static pressure to be applied simultaneously to both inside and outside of the pressure tube, thus protecting it from being destroyed.

Francke Flexible Coupling

Flange couplings are usually tied together with ordinary bolts, making a rigid joint. The Francke flexible coupling, marketed by the Smith-Serrell Co., 90 West St., New York City, is also an ordinary flange coupling



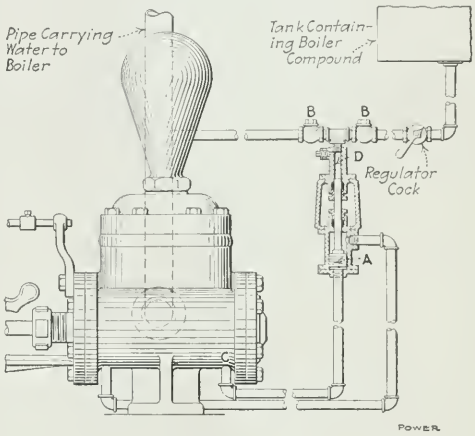
Francke Flexible Coupling

but is connected by flexible bolts. They are made of tempered-steel leaves, held at each end by a keeper which prevents their working loose. The keepers are slotted at each end to engage spring rings which fit in a groove in the coupling flanges.

All leaves except two short ones at each end are slotted. The short ones are held stationary, making all movement come on the steel leaves, which do the work that is distributed over a large area. The slots in the leaves allow the coupling to adapt itself to any misalignment of the shaft.

Taber Automatic Boiler-Compound Feeder

This compound feeder is designed to operate in unison with the boiler-feed pump and to automatically stop feeding when the pump stops. It can be attached to any make of pump. In reality the feeder is a water-operated



Taber Automatic Compound Feeder

plunger pump, the piston of which is actuated by the water pressure from the discharging ends of the boiler-feed pump. The plunger of the feeder runs in a cylinder, which is fitted at one end with a stuffing-box; the other end is connected to a tee to which the two check valves *BB* are screwed. One check valve is piped to the tank containing the compound solution, the other is piped to the discharge pipe of the boiler-feed pump. The arrangement is shown in the illustration. A regulating cock is piped in between the tank and the feeder by which the amount of compound fed to the boiler is adjusted.

The action of the compound feeder, which is built by the Taber Pump Co., Swan and Ellicott Sts., Buffalo, N. Y., is as follows: As the upper and lower sides of the plunger piston *A* are connected to the water ends of the water cylinder of the feed pump, when the pump plunger moves toward the end *C*, the water pressure produced in that end of the cylinder is exerted against the under side of the feeder piston *A*, which is forced upward, discharging the compound in the chamber *D*, out through the left-hand check valve *B*, into the discharge pipe, where it mingles with the feed water passing to the boiler.

On the reverse stroke of the boiler-feed pump water is forced into the feeder cylinder above the piston *A*, which forces it downward and a charge of compound is drawn into the chamber *D* from the compound tank. The discharge stroke then forces it into the feed water. For every stroke of the feed pump there is a corresponding stroke of the compound pump, and no water is fed to the boiler without receiving a certain amount of compound.

ELECTRICAL DEPARTMENT

Automatic Reversing Starter

By James A. Seager

Where a motor has to be reversed, unless special means are provided, it is necessary to have a main switch or circuit-breaker, a starting resistance and a reversing switch. These three separate items in the hands of an inexperienced person afford possibilities for mistakes, inasmuch as the use of them in the wrong order may mean trouble.

For this reason many devices have been put upon the market for making the control of reversible motors as automatic as possible. One of the latest of these is that brought out by Jules Hoffe, of Budapest, which is illustrated in Figs. 1 and 2, showing the front and back views respectively. This is a combination of a reversing switch, a resistance switch for inserting and cutting out starting resistance, and a main switch or series circuit-breaker, and also a dashpot for the switch lever of the resistance switch. These are mechanically connected so that they act successively in starting and stopping, and the motor can be started only with the entire series of starting resistance in circuit. Moreover, the current is not interrupted either on the reversing switch or on the resistance switch, but only on the main switch or series circuit-breaker. Hence the attendant has to watch only this one point.

The slab carries a pivot, about which the starting-switch lever moves. This lever carries a contact brush and also a lug at the top, which engages the series switch lever mounted on a pivot above it. This series switch lever is under the control of a spring tending to pull it toward the right so as to close the circuit. It is, however, prevented from doing so by the lug on the starting-switch arm so long as this is in its extreme upper position. On the lower part of the slab are mounted segmental contacts and a two-armed lever attached by a pin and connecting-rod to the starting switch. The ends of these contacts are so close together that in the off position of the switch they are connected by the brushes, and should the brushes slide over the ends, the circuit cannot be broken. The starting-resistance lever which is loose on its pivot moves with this contact brush over the contacts connected with the starting resistance, and has a lug normally resting against the lug of the lever of the connecting-rod. Thus the starting-resistance lever moves downward as soon as the short lever descends while it is raised again when the latter lever is moved upward. In order that the starting-resistance lever may move down slowly and gradually a dashpot is provided to control the motion.

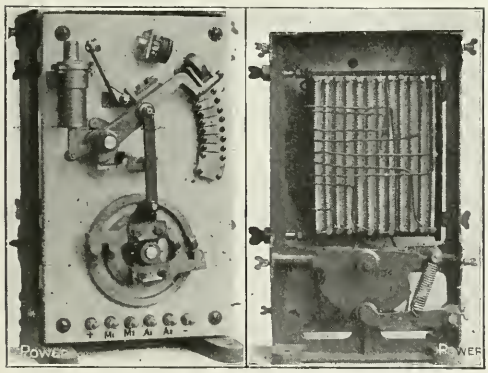


Fig. 1. Front View

Fig. 2. Rear View

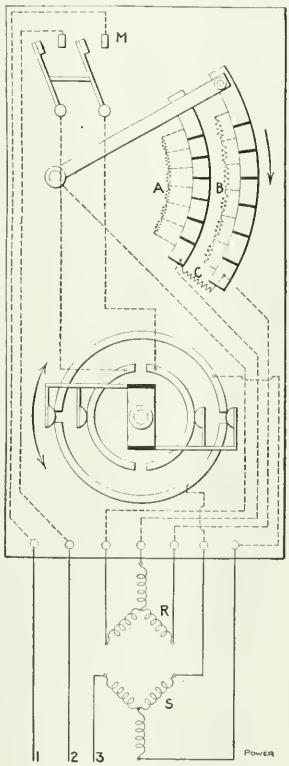


Fig. 3. Starter Applied to Three-Phase Current

Referring to Fig. 2 there will be seen a pulley fixed to the shaft passing through the slate at its lower end, and when this is rotated the brushes slide over the segmental contacts and at the same time the short lever in contact with the starting-switch lever is rocked downward by the action of the connecting-rod. If the pulley is moved in the reverse direction the brushes slide over the alternate contact segments, and thus the "change-

over" motion takes place, causing the motor to run in the reverse direction. Hence, the direction of rotation of the motor is fixed immediately before the current is supplied.

As soon as the starting lever commences to travel down, the lug on its upper surface clears from the projection on the lever of the series switch, and the spring pulls the latter into contact whereby the main circuit is closed.

By a very slight modification of the reversing contacts the apparatus may be adapted to three-phase work. This is illustrated in Fig. 3. Here *R* represents the rotor winding and *S* the stator winding of the motor. Two conductors are connected by means of a double-pole main switch *M* with the two inner contacts on the reversing switch, while the third conductor is connected directly to one phase of the stator. Three sets of starting resistance *A*, *B* and *C* are provided for the rotor, one placed in each phase while the primary winding is, of course, electrically insulated from the secondary.

Polarity of Line Wires

By A. E. Christophersen

When installing electrical machinery it is often necessary to locate positive and negative sides of a circuit before a piece of apparatus can be connected. Therefore, a few simple methods for determining the polarity of line wires will be given.

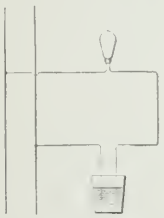


FIG. 1

FIG. 2

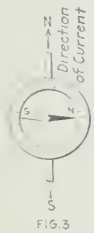


FIG. 3

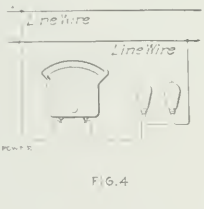


FIG. 4

Methods of Determining Polarity

A simple test is shown by Fig. 1, which represents the ends of two wires, one from each side of the circuit, placed about an inch apart in a glass of water. A suitable resistance, such as one or more lamps, should be in circuit. It is also well to reduce the resistance of the water by putting in a small quantity of salt. Bubbles of gas arise from each of the two terminals, but at a much greater rate from one than the other; that from which the least bubbles arise is the positive wire. It is not advisable to use this test on high potential circuits.

With the same apparatus a color test may be made. Instead of placing salt in the tumbler, throw in a few crystals of iodide of potassium and a small quantity of starch, then place the ends of the wire in the solution. It will be found that the electrolyte turns to a dark blue color near the positive wire. If some of the prepared solution is poured on a piece of white blotting paper and the wires are pressed against the paper, that part near the end of the positive wire will turn dark.

The compass test is based on the action of the magnetic lines set up around a wire carrying current on a magnet placed in the vicinity of the conductor. These magnetic lines are concentric with the conductor, their direction depending upon the direction of the current in the conductor. In Fig. 2 the conductor is represented perpendicular to the plane of the paper with the current flowing away from the reader. The direction of the magnetic lines is indicated by the arrow-heads. A compass needle placed in the magnetic field will tend to assume the position shown, its north pole pointing in the direction of the magnetic lines set up by the current in the conductor. If the current is in the opposite direction the lines of force will be in a counter clockwise direction, and the position of the needle will be reversed.

This test can also be made on a horizontal conductor. Select a part of the conductor that is placed or can be bent into an approximately north and south direction. Place the compass directly over the conductor, as indicated in Fig. 3. If the current in the conductor is flowing from south to north, the north pole of the compass will be deflected toward the east. If the current is flowing toward the south, the north pole of the compass needle will be deflected toward the west.

In order to obtain a proper deflection of the needle along the scale the positive ammeter lead must be connected to the positive side of the circuit, and the negative lead to the negative side of the circuit. If the connections are reversed the needle will be deflected in the opposite direction until its further progress is barred by a stop or by the side of the case. It is well in this test to use enough resistance in series with the ammeter so that the current through the instrument will be small. Allowing a large current to flow through the ammeter in the reverse direction may harm it by bending the needle. A small reading ammeter in series with a suitable resistance can be used in the manner illustrated in Fig. 4.

Voltmeters are sometimes used for testing the polarity of the wires, but it is not good practice as the needle is apt to be bent by the sudden rush of current in the reverse direction through the instrument coils if the connections are not properly made.

What Would Happen to Alternator?

A plant consists of two power houses, one containing 6600-volt, three-phase, 60-cycle alternators driven by Pelton waterwheels, and the other a Parsons steam turbine driving a similar alternator of 500 kw. All the alternators are run in parallel, the total power of the water-driven units being about 800 kw. The steam-driven units are excited by a 20-kw., 120-volt, direct-current generator belt driven from a small steam engine.

Suppose the belt were to break when the engineer is in the boiler room so the excitation of the field coils of the steam-driven alternator stopped. Would the armature be damaged by the current from the other alternators?

G. Howe.

Brittania Beach, B. C., Canada.

GAS POWER DEPARTMENT

Oil for Internal-Combustion Engines

Some interesting data on the present oil situation are contained in the report of the "Prime Movers Committee" of the National Electric Light Association, submitted at its recent convention. Quoting from a bulletin of the U. S. Geological Survey, the report gives the production of oil in this country as compared with the rest of the world for the past four years, as follows:

PRODUCTION OF OIL IN BARRELS

	1909	1910	1911	1912
East of the Rockies	127,224,000	136,547,000	139,315,000	133,200,000
West of the Rockies	54,776,000	73,010,000	81,134,000	87,000,000
Total in United States	182,000,000	209,557,000	220,449,000	220,200,000
Estimated world production	298,346,000	327,474,000	345,512,000	347,000,000
Percentage of United States production to world production	61.1	63 8	63.8	63.4

This shows that, although there was a decrease in the production east of the Rockies during 1912, this was compensated for by the increased production west of the Rockies, so that the total production in the United States during 1912 nearly equaled that of 1911.

In Europe the production has decreased, 60,000,000 bbl. being produced in Russia in 1912 as against more than 66,000,000 bl. in 1911. Roumania increased its product slightly but not sufficiently to offset the Russian decline. The world's consumption is approximately one million barrels a day.

Prices advanced steadily during 1912, the increase per barrel over those in 1911 in the various sections of the country being as follows:

Pennsylvania	70 c. increase
Illinois, Ohio, Indiana	35 to 40 c. increase
Texas	10 to 20 c. increase
California	5 c. increase

During the present year the prices have again advanced until now the Pennsylvania oils command a price nearly double that of a year ago.

The increased price of oil appears to have temporarily retarded the extension of the oil-engine business in the Eastern and Central states, although there are now in operation in this country over 300 installations of medium and heavy oil engines aggregating about 75,000 hp.

The report concludes with specifications for oil-engine fuels, abstracted from a paper by I. C. Allen, which was presented before the A. S. M. E. last winter. Mr. Allen's specifications were in part as follows:

Fluidity—Sluggish oils should be heated before being introduced into the engine. If it be necessary to use very heavy oils, the engine should first be warmed with a more fluid fuel, and the heavy oil introduced only after the engine is hot and running well. This process should be reversed when shutting down, and the heavy oils washed out of the engine valves and pipes with a lighter oil by running a short while on these lighter oils before allowing the engine to become cold.

Tarrying Content—An oil should contain not more than 4 per cent. of material insoluble in xylol, as a larger proportion of insoluble material will tend to form coke in the cylinders.

Free Carbon—There should be not more than a trace of free carbon in the oil, as this tends to stop the valves and carbonize on the surfaces of the cylinders.

Volatility—At least 80 per cent. should distill over at 350 deg. C. (662 deg. F.); greater than 20 per cent. residue at this temperature will show a large carbon content by coking.

Flash Point—The flash point should be between 60 and 100 deg. C. (140 and 212 deg. F.).

Incinerating Oil—In general, a heavy oil containing no flashy material should be enlivened by about 2 per cent. of a gas oil having a flash point 60 to 100 deg. C., or less, by mixing before introducing into the cylinders.

Specific Gravity—The specific gravity in itself, although of little significance, should not be greater than 0.920 (7.67 lb. per gal.); beyond this gravity the large proportion of heavy residual material would give trouble in the engine.

Calorific Value—This should not be less than 16,200 B.t.u. per pound, and the hydrogen content not less than 10 per cent., as lower values approach that of pure carbon and will give poor combustion.

Sulphur Content—The sulphur content should not be more than 0.75 per cent. Brass, zinc and copper are to be avoided in the surfaces exposed to combustion. Nickel-steel seems to be the best resistant material.

Acidity and Alkalinity Content—The oil should contain no free ammonia, alkalies or mineral acids, because of their pitting effect on the surfaces exposed to combustion.

Ash Content—The oil should contain not more than 0.05 per cent. of noncombustible mineral matter.

Water Content—A water content should not be greater than 1 per cent.

Paraffin Content—A paraffin content above 15 per cent. will give some trouble. A higher percentage of paraffin, because of the large quantity of oxygen necessary for complete combustion, will burn with difficulty.

Alphaltum Content—The heavy-oil engine, at least, as far as asphaltum oils are concerned, is still in its experimental stage, but it will not be unfair to assume that when the engineering difficulties are surmounted it will be practicable to burn any fuel oil containing asphaltum that is sufficiently fluid to flow, providing it be free from solid matter and water. An oil containing 21 per cent. asphaltum has been successfully burned.

Lubricating Oil

Viscosity—The viscosity should be between 9 and 10 deg. (Engler) at 50 deg. C.

Flash Point—The flash point should be between 220 to 240 deg. C. (428 to 646 deg. F.).

Carbonization—When agitated with concentrated sulphuric acid the oil should not lose more than 10 per cent. by carbonization. This sulphuric-acid test gives an indication of the quantity of unsaturated hydrocarbons present.

Solubility—The oil should dissolve completely and clearly in benzine.

Acidity—It should be free from acids and alkalies, as these pit the cylinders, and free from resins and fats, as these saponify.

Animal and Vegetable Oils—Because of their tendency to decompose, animal and vegetable oils should not be used.

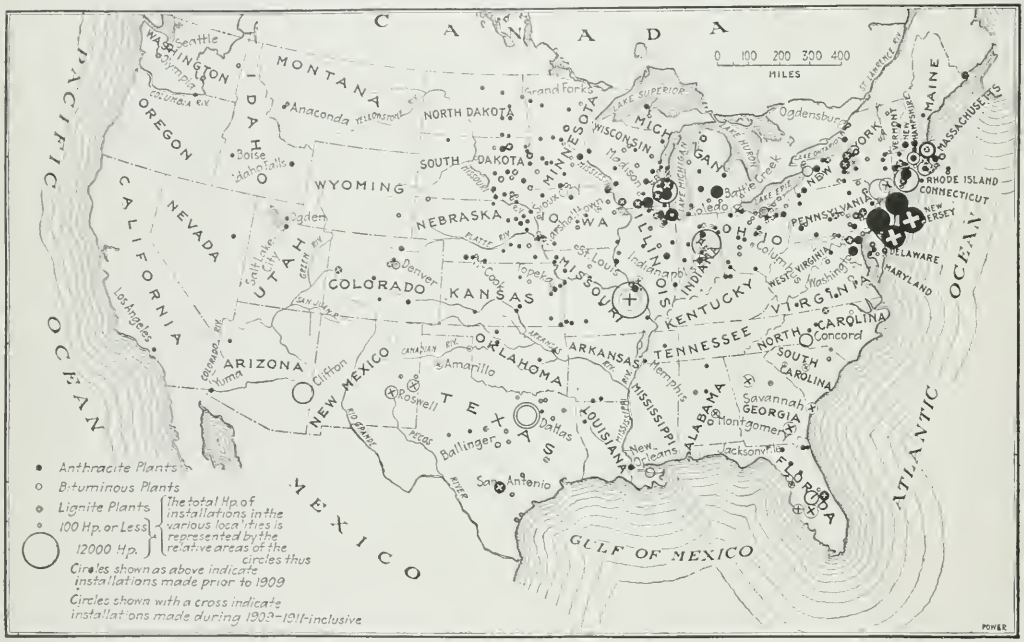
Producer-Gas Situation in the United States

An impression seems to prevail in many circles that the gas-producer situation in this country is at a standstill. That such an idea is erroneous, however, is shown in a recent investigation by Prof. R. H. Fernald, for the Bureau of Mines, the results of which are published as Bulletin 55 of that department.

This shows that the number of producer-gas plants installed during the past three years amounts to 52 per cent. of the total number installed during the preceding nine years. This is exclusive of additions to existing plants during that period. Expressed in terms of power it means that the horsepower represented by the installation during the past three years amounts to 68 per cent. of the total horsepower installed during the preceding nine years. The distribution of gas-producer plants in the United States is shown on the map.

In spite of this gratifying situation, a canvass of producer manufacturers revealed an attitude of uncertainty and expectancy; the first because of present oil-engine activities, and the second in the hope for a marked development in the bituminous gas producer. Owing to the increase in the price of oil and the difficulty in obtaining long-term oil contracts, however, the competition of the oil engine is not as keen as was at first expected.

Taking up the considerable number of unsuccessful, or only partly successful producer installations during the early period of this development, the report attributes these largely to three causes: First, there was too much theory and too little practical knowledge in the design of many of the early producers. Second, there was a scarcity of competent labor. Third, in a number of instances, salesmen totally unfamiliar with the requisites of a successful producer installation, had misled prospective customers in the belief that no matter what the customer required in the way of a power plant, a producer plant would give the best satisfaction. In consequence, many of the installations were unable to live up to the results guaranteed.



Map Showing Distribution of Gas-Producer Plants in the United States

By 1912, however, these conditions appear to have been rectified to a large extent. Manufacturers have followed up and overcome many of the defects in design and salesmen are no longer making extravagant claims, but instead each individual case is now receiving the attention of the engineering department. In this connection it may be mentioned that it is no longer the tendency to overrate the capacities of producer plants, as was the custom a few years ago.

As regards labor, managers report less trouble from incompetent help than formerly. With special reference to bituminous producers the report says:

The Government investigations at St. Louis and Norfolk demonstrated without question that both the updraft and the

owndraft types will generate an excellent gas from bituminous coal, entirely suitable for commercial operation of gas engines.

There are, of course, inherent difficulties in each type, such as the mechanical extraction of the tar in the updraft producer, which reduces the efficiency of the plant and forces on the owner an undesirable byproduct, and the excessive labor in cleaning the downdraft system, the requirements of cleaning also prohibiting the continuous operation of a single generator unit. Undoubtedly, modifications will be made that will reduce these objections to a minimum, and other developments will gradually simplify such plants; but even as the plants exist today, the fact is that approximately 32 per cent. of the total producer-gas horsepower in this country is developed from bituminous coal and lignite.

The updraft producer for bituminous coal using a centrifugal scrubber, has been generally successful. From our knowledge of the double-zone producers, we believe that the question of the main filling with lamp black and soot is a very serious problem, far greater than the mechanical disposal of tar.

Bituminous producers in large units with proper auxiliarises are successful, but the small bituminous producers, owing to costs and difficulties of tar extraction are not as yet entirely successful.

The report concludes with some useful cost data on producer installations. These are in part included in the accompanying tables.

TABLE 1. COST OF PRODUCER-GAS ENGINES, 1912

Horsepower	Cost F.O.B. Factory	Cost of Engine Erected Including Foundatioo	Cost per Horsepower F.O.B. Factory	Cost per Horsepower Erected Including Foundations
45	$1,950	$2,400	$43 30	$53.30
50	2,000	2,500	40 00	50.00
50	2,200	2,500	44 00	50 00
55	2,250	2,700	40 90	49.10
75	3,300	3,850	44 00	51.30
100	3,850	4,475	38 50	44.75
100	4,000	4,400	40 00	44.00
100	4,000	4,600	40 00	46.00
125	4,500	5,150	36.10	41.30
150	5,800	6,670	38.70	44 50
165	6,800	7,550	41.20	45.80
180	6,500	7,500	36.10	41.70
190	8,500	9,250	44 75	48.70
200	7,000	....	35.00	.....
200	7,800	8,920	39 00	44 85
200	8,500	9,500	42.50	47.50
200	....	9,700	....	48 50
250	8,500	....	34 00	.....
250	9,200	10,500	36.80	42.00
250	10,600	11,600	42 40	46 40
300	10,200	....	34 00	.....
300	11,500	13,125	38 30	43.75
300	11,800	12,900	39 30	43.00
300	12,500	13,500	41.70	45.00
500	16,000	18,000	32.00	36.00
500	17,000	....	34.00	.....
500	20,000	22,500	40.00	45.00
1000	31,000	35,000	31.00	35.00
1000	34,000	....	34.00	.....
1000	35,000	39,000	35 00	39.00
3000	90,000	101,500	30 00	38.85

TABLE 2. COST OF GAS PRODUCERS, 1912

Horsepower	Cost F.O.B. Factory	Cost Erected Including Foundation	Cost per Horsepower F.O.B. Factory	Cost per Horsepower Erected Including Foundation
15	$396	....	$26 40	.....
15	450	$500	30 00	$33.35
25	455	....	18 20	.....
25	560	625	22 40	25.00
35	560	....	16.00	.....
50	700	....	14.00	.....
50	730	820	14 60	16.40
50	900	1,035	18 00	20 70
50	1,400	1,800	28 00	36 00
75	910	....	12.15	.....
75	940	1,050	12.50	14.00
100	1,050	....	10 50	.....
100	1,100	1,230	11 00	12.30
100	1,200	1,380	12 00	13.80
100	1,450	1,850	14 50	18.50
100	....	2,400	....	24.00
150	1,295	....	8 65	.....
150	1,530	1,710	10.20	11.40
150	1,600	1,840	10 65	12.30
150	....	3,300	....	22.00
200	1,725	....	11.50	.....
200	2,050	2,300	10 25	11.50
200	2,200	2,750	11 00	13 75
200	2,800	3,220	14 00	16.10
200	3,000	3,700	15 00	18.50
200	....	4,000	....	20 00
250	2,100	....	8 40	.....
250	2,600	2,900	10 40	11 60
250	3,500	4,300	14.00	17 20
250	....	4,750	.....	19 00
300	2,700	3,500	9.00	11.65
300	3,200	3,600	10 65	12.00
300	3,400	3,910	11.35	13 05
300	....	5,700	....	19.00
500	6,000	7,000	12 00	14 00
500	8,500	10,000	17 00	20 00
500	....	9,400	.....	18.80
1000	12,000	13,500	12 00	13.50
a1000	14,500	17,000	14.50	17.00
1000	....	18,700	....	18 70
a3000	40,000	44,000	13 25	14.65

TABLE 3. COST OF PRODUCER-GAS INSTALLATIONS, 1912

Horsepower	Cost of Gas Producer and Engine Erected Including Foundations	Cost of Complete Plant, Exclusive of Buildings*	Cost of Complete Plant Including Buildings*	Cost per Horsepower Gas Producer and Engine Erected Including Foundations	Cost per Horsepower Complete Plant Exclusive of Buildings*	Cost per Horsepower Complete Plant Including Buildings
50	$4,300	$5,300	....	$86.00	$106.00	....
100	6,250	7,800	$9,100	62 50	78 00	$91.00
100	12,460	15,800	17,500	62 00	79 00	87 50
200	13,200	16,200	.....	66 00	81 00	....
250	14,800	18,200	.....	58 20	72 80	....
300	17,000	22,000	23,800	56 65	73 35	79.35
500	25,000	29,500	.....	50 00	59 00	....
500	32,500	47,500	.....	65 00	95 00	....
1000	48,500	57,500	.....	48 50	57 50	....
1000	56,000	84,000	.....	56 00	84 00	....
3000	145,500	202,000	.....	48.50	67 35	....

*This includes producer, engine, electric generator, piping, switchboard and auxiliaries, all erected with suitable foundations.

Canada's Largest Power Station

Work has been started on the hydro-electric power station of the Cedar Rapids Manufacturing & Power Co., Montreal, Que., which, when completed, will be the largest in the Dominion of Canada. Its initial rating will be about 100,000 hp., and later on this will be increased to 160,000 hp. The site is at Cedar Rapids, in the St. Lawrence River, about 30 miles above Montreal.

The plant will be 663 ft. long and 130 ft. wide and will be built as a part of the dam. The intakes will be of the scroll or involute type. Orders have been placed by the Cedar Rapids company for the generating equipment. This includes twelve 10,800-hp. waterwheels, which are to operate at 56 r.p.m. under a head of 30 ft., and will be the largest ever built. There will also be three 1500-hp. exciter units which will operate under the same head at 150 r.p.m. Twelve generators are to be connected to the waterwheels.

The design of the turbines will be very much the same as that of the wheels for the plant of the Mississippi River Power Co., at Keokuk, Iowa. The chief difference will be in arranging for carrying the weight of the generator rotor and the moving parts of the turbine on a thrust bearing above the generator instead of below, as is done with the Keokuk turbines. The waterwheel contract includes the turbine complete, the shaft running through the turbine and generator, the thrust-bearing support or truss to be located above the generator, also the thrust bearing complete. The weight of the generator will be taken through cast-iron supporting barrels through the turbine to the foundation below. The main units will be of the single-runner vertical-shaft type and will be installed in wheel chambers of spiral shape formed in the concrete foundations of the power house. The exciters will be of the same type but smaller in size. The runners for these wheels will be an enlargement of a model runner which under test at Holyoke gave an efficiency of 90 per cent.

About 100,000 yd. of concrete work and 2,000,000 yd. of rock and earth excavating will be necessary. Contracts for 80,000 hp. of the output of this station have already been closed. Of this, the Aluminum Co. of America will take 60,000 hp. and the Montreal Light, Heat & Power Co. will take 20,000 hp. It is expected that the plant will be finished in October, 1914.

HEATING AND VENTILATION

Steam and Electric Load Curves in Large Buildings

The relation between the steam requirements for heating and electric loads in large buildings is a question upon which very little accurate data are available. This year the committee on heating of the National Electric Light Association collected a number of curves typical of different types of building and presented some of them in the report. This interesting collection of curves is reproduced herewith.

The charts include curves showing the steam requirements of the building and curves showing the steam which would be required for the electricity actually consumed, based on a factor of 60 lb. per kw.-hr. In the case of some buildings where pumps or steam-driven elevators are installed, there is an additional curve showing the high-pressure steam required for these pumps, and a curve showing the total steam which would be available for exhaust from both the pumps and electric units, if they were installed. The curves show the actual steam required, and in the case of the curve showing steam available for exhaust, a slight deduction should be made on account of the condensation removed by steam and oil separators.

Fig. 1 shows the steam and electrical requirements of a department store in Detroit on a typical winter day. This store is a brick building of five stories, having cubical contents of 1,545,000 cu.ft. and a connected steam radiation of over 10,000 sq.ft. There are also installed in the store a duplex steam pump, 18x12 in., and a house pump, $12\frac{1}{4}$x10 in. The store is open for business from 8 a.m. until 5:30 p.m.

Fig. 2 represents the steam and electrical requirements during a summer day of a large department store in Chicago. This building is eight stories in height and the cubical contents are approximately 7,800,000 cu.ft. In addition to radiation for both direct- and indirect-steam heating, there is required steam for 16 elevators and for boiler-feed pumps. Fig. 3 shows the steam and electrical requirements in the same department store during the holiday trade, in ordinary winter weather, and Fig. 4 during severe winter weather.

Fig. 5 shows the steam and electrical requirements in an office building in Detroit. This is an 8-story building of brick construction having cubical contents of 565,000 cu.ft. and connected steam radiation of 6600 sq.ft.

Fig. 6 shows the steam and electrical load in an office building in New York. This is a 24-story building, having cubical contents of 6,500,000 cu.ft. and having 63,140 sq.ft. of radiation connected. This is a composite curve averaging 28 typical winter days.

Fig. 7 shows a large office building in St. Paul. This is a steel and brick building, 16 stories high, having cubical contents of 1,907,800 cu.ft. and connected steam radiation of 19,500 sq.ft. This diagram shows conditions on a typical winter day in St. Paul. Steam is kept on all night in cold weather, thus giving a more even steam line than for some of the buildings.

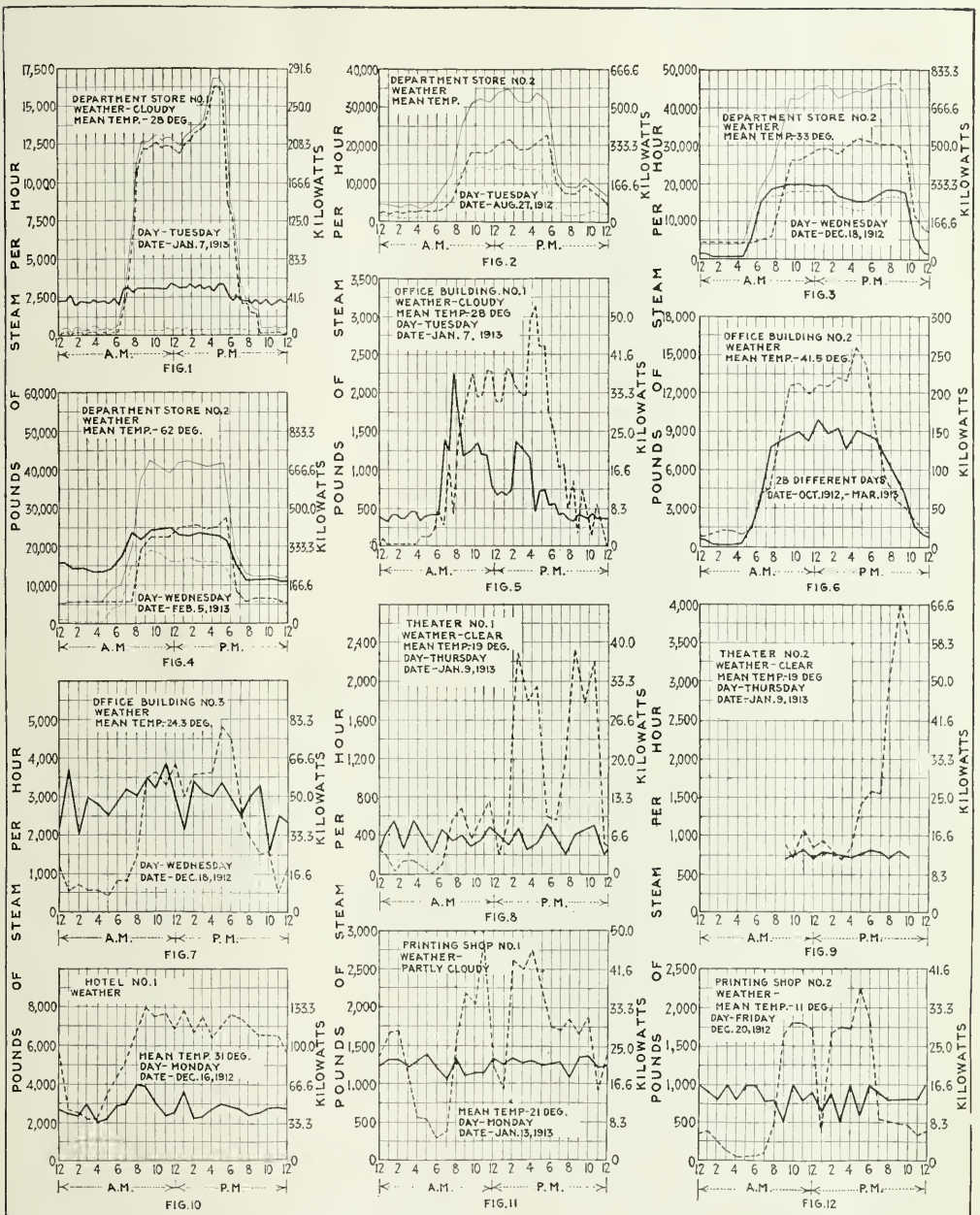
Fig. 8 represents the steam and electrical requirements in a theater in Detroit. This is a five-story building of brick construction, having cubical contents of 710,000 cu.ft. The steam for the office portion of this building, however, is not shown in the diagram, simply the steam and electrical requirements in the theater. This curve shows that there are two performances each day in the theater. Fig. 9 is a diagram for another Detroit theater. This building is brick, with a stone front, having cubical contents of 750,000 cu.ft. The steam for the office building is not shown in the diagram. Fig. 10 shows the steam and electrical requirements of a large hotel in St. Paul, on a typical winter day. This is a 12-story building, of tile and steel construction, having cubical contents of 2,308,270 cu.ft. The heating load in this building is fairly uniform and the steam required for the electrical load is not only variable, but runs far in excess of the steam used for heating.

Fig. 11 shows the steam and electrical requirements in a printing shop in Detroit. This is a five-story brick building, having cubical contents of 315,000 cu.ft. and a connected steam radiation of 4008 sq.ft. The hours for this shop are 7:30 a.m. to 5:15 p.m. There is also a night shift with regular hours.

Fig. 12 represents a printing shop in St. Paul. It is a four-story brick building, having cubical contents of 695,320 cu.ft. and connected radiation of 9529 sq.ft. This is a publishing and printing house, and the hours for the night shift are irregular. It will be noticed that the electrical load is used principally in the daytime.

Comments on the charts follow to the effect that even in the winter time, when the heating and power requirements more nearly approach each other, there is still a wide variation in the two curves, some showing that at certain periods of the day the demand for steam for heating is in excess of the demand for electricity, while at other periods of the day the demand for electricity is greater than the demand for heating. In view of the fact that the steam demand for heating disappears altogether in the summer, and in the winter is not coincident with the demand for electricity, the utilization of exhaust steam for heating in isolated plants, in the opinion of the committee, is not nearly as great a factor in economy as has sometimes been claimed. The question is not whether heating can be done economically with exhaust steam, but whether the entire plant can be operated economically. In the most modern buildings the heating load constitutes a comparatively small part of the total requirements of the building.

When the electric load for the year is considered it will be seen that an isolated plant produces a large amount of steam for electrical energy uneconomically in order to make a comparatively small economy in steam heating. In other words, in attempting to secure a small economy, a greater economy is lost sight of.



STEAM AND ELECTRIC LOAD CURVES FOR VARIOUS TYPES OF BUILDINGS

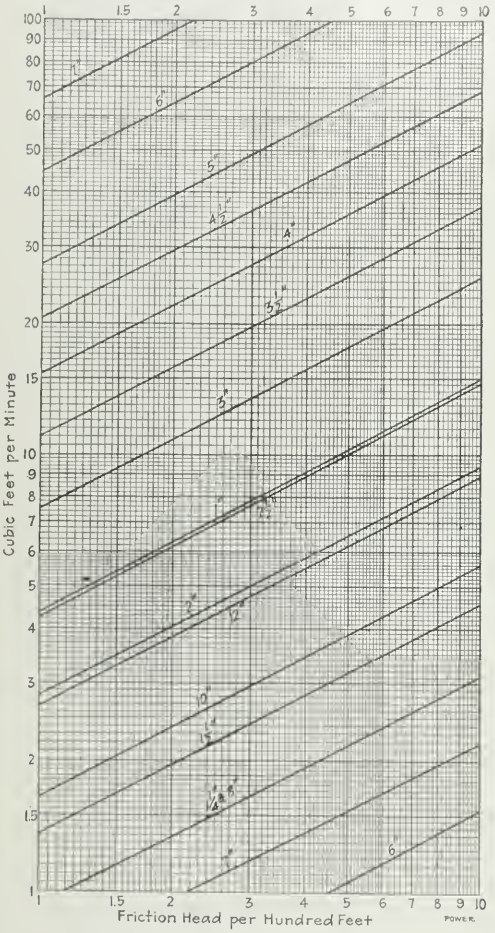
POWER

Flow of Water in Pipes

By W. L. Durand

In problems relating to the flow of water through pipes there are five variables which must be considered. These are: Quantity of water, size of pipe, velocity of flow, length of pipe, friction head.

The last two may be reduced to one variable "friction head per unit length," such as "per hundred feet."


Cubic Feet per Minute
Friction Head per Hundred Feet
POWER
For 1-Inch Pipe Divide the Vertical Scale by 10. For Pipes 6 to 12-Inches in Diameter Multiply the Vertical Scale by 100

Quantity of Water, Friction Head and Size of Pipe

In the **July 9,** 1912, issue, Mr. Evans gives a list of the best known **formulas** for the flow of water in pipes. He also gives a **table of** friction heads and velocities with values derived from each of the formulas for the different commercial sizes of pipe. Based on the average of these values the writer made a set of curves on logarithmic paper which was published in the Oct. 29, 1912, issue. Using these curves I have worked up a second set of curves between quantity of water, friction head and size of pipe. These are presented in the accompanying chart.

Any equation of the form $y = bx^n$ may be plotted as a straight line on logarithmic paper, and *vice versa* any straight line on logarithmic paper may be reduced to the form $y = bx^n$. It is also possible to reduce a set of curves between three variables, which are straight lines on logarithmic paper, to the form $y = bx^n z^m$.

Without going into the method employed the accompanying curves reduce to

$$V = 0.4\, d^{2.64} h^{0.53}$$

From this formula the following formulas may be derived, by the use of which any one of the four variables mentioned above may be found if any other two are known.

$$V = 0.327\, d^2 v$$

$$v = 1.22\, d^{0.64} h^{0.53}$$

$$v = 3.06 \frac{V}{d^2}$$

$$h = \frac{5.6\, V^{1.89}}{d^5}$$

$$h = \frac{0.69\, v^{1.89}}{d^{1.21}}$$

$$d = \frac{1.42\, V^{0.38}}{h^{0.2}}$$

$$d = \frac{0.73\, v^{1.56}}{h^{0.83}}$$

in which,

V = Cubic feet per minute;
v = Velocity in feet per second;
h = Friction head in feet per 100 ft.;
d = Actual internal diameter of pipe in inches.

From the first formula it is also possible to make an equalization table similar to that in use for steam pipes. In using such a table the quantity of water and friction head per unit length are constants and the diameter is the only variable. If, then, in the formula

$$V = 0.4\, d^{2.64} h^{0.53}$$

V and h are taken as constants, and d as a variable, all that is necessary to make this table is to take the actual diameters and raise them to the 2.64 power. This table is as follows:

Dia., In.	Equalization Factor
1	1.13
1½	2.34
1¼	3.52
2	6.80
2½	10.86
3	19.3
3½	28.3
4	39.5
4½	53.3
5	71.7
6	116
7	172
8	240
10	440
12	700

By the use of this table the size of pipe equal to several smaller pipes may be determined so that the friction loss per unit length will be the same in all.

What size pipe should be used to feed four 3½-in. pipes? From the table, 28.3 is given as the equalization factor for 3½-in. pipe. Then

$$4 \times 28.3 = 113.2$$

The nearest size pipe to this factor is 6 in., which will feed four 3½-in. pipes with the same friction loss in all.

EDITORIALS

Educational Work in Summer

Now that the summer is here, the educational work so vigorously carried on by many engineering organizations during the winter will be discontinued. The number in attendance at the meetings will consequently decrease and interest in the organizations will, in a measure, be weakened.

In the sultry evenings of summer a trip to the beach, a trolley ride or the hammock in the yard—if one is so fortunate—are all more desirable than the smoke-laden atmosphere of the usual illy ventilated meeting room. Discussion of troubles or of the questions asked on the floor should not cease. Power plants have their summer troubles, although they are not usually so numerous as in winter; nevertheless, there is always a variety of subjects, discussion of which is beneficial.

Above all, do not wait until late in the fall to appoint educational committees. Appoint them now so that a thorough educational campaign may be prepared and ready to produce good results as soon as the season opens in the fall.

Care of Boiler-Furnace Breechings

Some engineers regard the breeching or flues of boiler furnaces as little more than a sewer for carrying away the waste products of combustion, which, if allowed to get into the room, would pollute the atmosphere.

Breechings do not require much attention normally and it is because of this, perhaps, that they do not receive attention when they are much in need of it. The effective area of opening in most breechings is none too large even when the breeching is clean. When the breeching, flues and setting are allowed to accumulate soot the draft is not only impaired, but may become inadequate to meet heavy loads. If forced draft is used and a condition of soot accumulation exists and the settings, flues, etc., leak, the pressure within will force the gases into the room. If this leakage of gas becomes chronic and the damper regulators are known to be working well, it indicates obstructed flues and breechings.

Instances where natural draft has displaced forced draft and one or more boilers have been cut out of service after the breechings have been properly cleaned are not unknown.

Where natural draft prevails and the boilers are working hard, steps should be taken to stop leaks in the breeching. A leaky breeching containing much soot may give enough draft while the fuel bed is thin and the load about normal, but with a thick fuel bed and sudden demands for steam, serious trouble is likely to be experienced.

Cleanliness is admirable, but if as much attention were given to cleaning boiler settings, flues, tubes, etc., as is given to rubbing alcohol on a marble switchboard or polish on brass rails, the coal bill might be materially reduced in many plants.

On the Wrong Tack

When discussing the disadvantages of an isolated plant, advocates of the central station are prone to minimize the question of heating. Considering the fact that this is one of the factors which has deprived them of a great deal of business it is not surprising that their interests rather than an unbiased engineering analysis should dictate their viewpoint.

On other pages of this issue appear a number of charts, showing the steam required for electric and heating loads in different types of building, as prepared by the committee on steam heating of the National Electric Light Association. High-speed automatic engines using sixty pounds of steam per kilowatt-hour were taken as a basis and it was shown that the steam required to generate the electrical load was considerably in excess of the amount needed for heating. The two loads were not coincident, and, in short, using exhaust steam for heating under the circumstances mentioned, was an attempt to secure a small economy by losing sight of a greater economy, the greater economy meaning, we take it—central-station current and separate steam service.

No doubt there are a great many small noncondensing plants in which the steam consumption runs well up to sixty pounds per kilowatt-hour, but with a rate from the central station which should include a percentage for large overhead charges and some addition for profit, and considering the extra cost of heating, even these plants should make a favorable showing. When exhaust steam from an engine is used for heating about eighty-five per cent. of the initial energy is available, so that if the power load is in excess there is no need for a separate source of supply. Good practice would be to lower the steam rate on the power load, as there is no real occasion for discharging so much excess steam to atmosphere.

Without condensers, a compound engine, or a single-cylinder, four-valve unit would reduce the steam consumption by 30 to 40 per cent., and in most cases there would still be enough steam for heating. A further reduction in steam rate would be possible by installing a condenser, which would carry the summer load and the excess of power over heating.

The argument against a condenser in an office building is "cooling water." Water at high cost would, of course, soon counterbalance the efficiency added by the condenser. It would then be necessary to turn to the cooling tower, and, although the use of this apparatus is not common in office-building plants, there are types which will give satisfactory service at a cost of about one pound of water for every pound of steam condensed. The amount of water used, due to the lower steam rate, would then be lower than in noncondensing plants of the best type, and the excessive use of water for cooling would be obviated.

There is the possibility of using hot-water heat and operating condensing even on that part of the load supplying the heating. The vacuum in the condenser can be regulated to suit the temperature of water required, or

the load can be shifted from the unit carrying the heating to the unit running full condensing, or *vice versa*, so that the required amount of steam can be obtained to give almost any temperature of water. The head in unusually high buildings might require a division of the system into sections, but in the ordinary building there would be no difficulty in operating a hot-water system.

The additional first cost of the refinements just mentioned would prohibit their use in plants under, say, two to three hundred horsepower. For larger plants a thorough investigation would be worth while before a decision is made on the equipment of the plant.

These are a few of the arguments that the heating committee might have included in their report had they any intention of treating the subject fairly. If continued confidence in their analyses is expected, a change in methods is necessary. A fair and equal presentation of the facts for both sides is all that is asked, and generally this would be enough to swing the pendulum toward the isolated plant. In engineering discussions there is no room for commercial quibbling, for any omissions or deductions unfair to one side tend to act as a boomerang discrediting those participating.

Graphite in Boilers

POWER has printed considerable in the last year on the use of graphite in boilers to remove or prevent scale. Most of this was given in the form of letters from readers telling their own experience and all of these letters confirmed the efficacy of the treatment. Then came the announcement in a paper by Lieut.-Com. Frank Lyon, U. S. N., before the American Society of Naval Engineers, that graphite in boilers accelerated corrosion and was, therefore, to be classed with "Dangerous Compounds." This seemed too important a criticism to be ignored, and it was decided that before more was printed on the subject all effort should be made to uncover the real facts.

A number of manufacturers of boiler graphite were written to and all maintained that there was no truth in Lieutenant Lyon's contention. All but one of them had evidence to offer and that one dismissed the question as too ridiculous for serious consideration. The most thorough refutation so far presented is the report, printed on page 37.

Another manufacturer also reported on an investigation of a marine boiler that was supposed to have been injured by the use of graphite. Pitting developed after removing the zinc, which had been in the boilers to prevent corrosion. Because graphite was being used, it was charged that the corrosion was due to it. The report affirms that pitting would have resulted without the graphite, and there seems no reason to question this. Corrosive agents in the feed water would do the mischief.

At the recent meeting of the International Railway Fuel Association the question came up and the following, quoted from the *Railway Age Gazette*, is also reassuring:

> The use of pure amorphous graphite was strongly recommended as it is purely mechanical in its action, having a tendency to break off the scale as well as preventing its formation. A simple laboratory experiment was made by applying this grade of graphite to one side of a plate and intermittently boiling. After 80 hours, extending over a period of 10 days, the graphite was still as active in its protection of the plate as it was originally. The opposite side of the plate was rusty.

Apparently the sum and substance of the situation is that graphite, at least in the proportions in which it is used in boilers, has no effect, so far as corrosion is concerned, either to cause it or to prevent it (unless it thoroughly coats the metal) and is to be regarded as simply inert except as a scale remover. In that capacity its action seems to be purely mechanical and not chemical.

Rate Decisions

The excellent work which the New York Public Service Commission of the second district has accomplished under the able chairmanship of F. W. Stevens, whose term has just expired, is again brought to our attention in the recent ruling in the Buffalo rate case. In fixing the rate schedule the commission acted upon the theory that the stockholders were entitled to a reasonable return upon the actual investment, but that the public should not be made to pay a return upon factitious intangibles. Wherever a difference arose as to the physical value of any property the commission, in every instance, gave the company the benefit of the doubt, but it was firm in refusing to permit such items as franchise, "going concern value" and certain alleged contracts to be considered as part of the capital stock upon which a return should be made. Moreover, reference to page 39 of this issue will show that the rate differential is based largely upon the connected load, a point that meets one of the usual central-station contentions.

Comparison with the present New York Edison rates shows that the people of New York pay from one and one-half to over three times as much for electric energy as do the people of Buffalo, the greatest hardship coming upon large residences and storekeepers.

Hearings in the rate case against the New York Edison Co. have been dragging on before the Public Service Commision of the first district for the past two years. This delay has been occasioned to some extent by the pressure of subway matters, which occupied a large part of the commission's time last year. Now that these have been disposed of, it is only reasonable to expect that the decision in the Edison case will be hastened. If the commission has ever felt any doubt as to its power to prescribe rates, the precedent established by the up-state commission should now pave the way.

The Christie air-steam engine is again in evidence. The Clinton (Iowa) *Herald* of June 1, prints a three-column advertisement in the form of an article, illustrated with a picture of one of these engines, weighing 46,500 lb., which will be installed about July 1 at the Clinton Paper Co.'s mill. The article winds up with the usual allusion to the present opportunity to obtain stock under especially favorable conditions. Before investing money in it, we should recommend reading the files of POWER as follows:

Christie air-steam engine, p. 382	Sept. 5, 1911
Discussion letters on same, p. 528	Oct. 3, 1911
p. 934	Dec. 19, 1911
p. 166	Jan. 30, 1912
p. 483	Apr. 2, 1912
Christie air-steam engine, by John T. Christie, p. 609	Oct. 17, 1911
Editorial, p. 603	Oct. 17, 1911
Performance of the field engine, by L. B. Lent, p. 721	Nov. 7, 1911

Who said the gas-engine business was moribund? The C. & G. Cooper Co., of Mt. Vernon, Ohio, have twenty orders now in the shop, and others offering if they could promise delivery.

READERS WITH SOMETHING TO SAY

Correct Position of Gate Valves in Horizontal Steam Lines

I would be pleased to be advised by readers as to the proper position for gate valves in large horizontal steam lines. There seems to be a difference of opinion on this point, although the general practice in this locality is to place the valve with the stem horizontal.

Experience here indicates that when a globe valve is so located that no condensation can accumulate above it, and it never changes temperature under pressure, the pressure should be on the under side of the disk. If the valve is in an undrained vertical pipe in a steam hose or flue blower, tank heater, or similar position so that condensation can accumulate and cool above the valve, it should be piped with pressure on top of the disk. This will avoid cutting out the disk and seat, due to the valve shrinking open when it cools. Obviously there should be a cutoff valve where the branch comes off, which can be closed to pack the globe valve.

D. L. Bellinger.

Glens Falls, N. Y.

Curves Showing Year's Output of Plant

The accompanying graph, compiled for the year of 1912, shows the operation of a 300-hp. power station furnishing heat, light, power and compressed air. The direction of the wind, velocity and temperature were obtained from the weather bureau and the graph shows

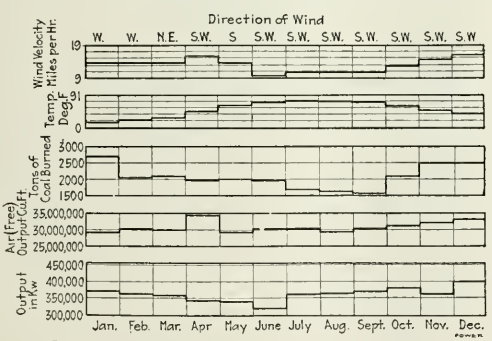


Chart Covering Year's Output of Plant

in a marked degree the influence of these three factors on the consumption of coal.

It should be noted that in the month of March, the electrical output decreased while the coal consumption increased. The temperature increased but the general direction of the wind was northeast. North and northwest winds affect the radiation from the building materially. This accounts for the increase in coal consumption at this time.

The sudden increase in kilowatt output for July is due to the increased amount of current necessary to operate the ventilating fans at high speed. The drop in output for November shows that these fans were slowed down to a speed necessary to give the proper ventilation for the heating season. On account of mechanical troubles with the cooling tower it was not possible to keep the exhaust turbine in continuous operation until the first part of July. It was kept in continuous service from that time until the first of October. During these three months, it will be noted, the coal consumption gradually decreased until Oct. 1, when the turbine was shut down and exhaust steam was turned into the heating system. At this point the wind velocity gradually increased and the temperature decreased.

F. J. Ravlin.

Chicago, Ill.

Shaft-Aligning Troubles as Infuenced by Belts

There have been a few articles published with regard to shaft aligning with the new patented instruments. These articles have mentioned the great saving made, but have not given any specific figures. I have been doing some of this work and have discovered several points not brought out in any article I have read.

A line of shafting, motor driven, was picked out and ammeter and voltmeter readings taken. The shaft was then aligned and found to be both out of line and out of level. After aligning, readings were again taken and a large reduction in friction looked for. Instead we found considerable more friction than before the shafting was touched. A close examination showed that the shaft, where it had been out of line, was always in the direction of belt pull to the countershafts. Where the shaft was lined up it tightened all the belts and the extra friction due to tight belts was more than was gained by the straight shafting.

Of course, the proper way would be to lengthen the belts to the same tension they had before the shaft was aligned. But just how is this to be accomplished? A test could, of course, be made without belts, but this hardly meets running conditions. In our case the belts were not tightened sufficiently to warrant putting in a new piece and yet they were tightened enough to neutralize the good work of the instrument. Until we have a reliable instrument for measuring belt tensions, a test of this nature will at least be open to question.

The experiment also demonstrated the fact that, although there is probably a large loss through line shafts out of line, there is probably a greater loss through belts unnecessarily tight. The trouble is, of course, with the man who does the lacing. A belt begins to slip and this man is called on. Instead of taking up just enough

to carry the machine nicely he takes up all he can get, probably with the idea that it will be a longer time before he is again called on. This, of course, results in stretching the life out of the belt and increasing the friction load on the engine.

When aligning shafting having old-style hangers which are not adjustable, except by shimming, at least six men should be on the job if the work is to be quickly done, as one man at the instrument can take care of that many working on the hangers.

Work in a gallery must generally be done when everything else is shut down, as the vibration so affects the instrument that it is impossible to work at all closely.

This letter may seem to indicate lack of faith in the shaft-aligning instrument, on the part of the writer, but such is not the case. The instrument will prove both a time and money saver where considerable shafting is to be cared for. In order to show results, however, it will be necessary to get after the belt lacer as well as the person directly responsible for the badly aligned shafting.

JOHN BAILEY.

Milwaukee, Wis.

Guide Point for Boiler Tubes

When it is necessary to remove a tube in the third or fourth row from the bottom it is generally cut free at each end and pushed or drawn out through the front header, quite a laborious job. The tubes are usually covered with ashes or soot scale, which must be removed

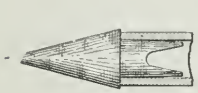


FIG. 1. CONE-SHAPED PLUG

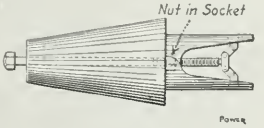


FIG. 2. POINT WITH LINK ATTACHMENT

before the tube can be drawn through the tube hole. When putting in new tubes there is trouble of a different character.

In most all horizontal water-tube boilers there are vertical brick baffle walls to direct the gases across the tubes several times before they reach the uptake. These baffles are easy to assemble while erecting the boiler and will last many years under ordinary conditions. Some of the baffles are of a special form of firebrick, placed between the tubes, but often have a bar across the back to keep them in place. Others are held in place by special shaped iron plates, which are afterward covered with about 2 in. of plastic asbestos to protect them from the fire.

Now these plates and firebrick fit snugly about the tubes and are frequently loose enough to drop down ¼ in. into the opening from which the tube was drawn. It requires patience to push the tube through the opening, even though it were ⅛ in. larger than the tube, but to have the plates or firebrick come down and partially close the opening, and with no other means than a long bar to remove them requires time and labor. Many tubes have been so badly battered on both ends by driving on them in an effort to break the firebrick obstruction that they were unfit for use after they had been driven into place.

To overcome this difficulty a cone-shaped plug, Fig 1, was made to fit in the end of the tube. This did very well, but frequently got stuck between the firebrick and considerable trouble was encountered in removing it.

Next an iron point was made partly hollow, for lightness, with long prongs, to extend back into the tube. Between these prongs a pair of links, attached to the end of a bolt, were fitted, which extended from the point through a nut fitted into a socket between the horns, as shown in Fig. 2. By tightening the bolt, the prongs are made to tightly grip the inside of the tube, which prevents the device from drawing out of the tube end if it is necessary to withdraw the tube after it has once been entered.

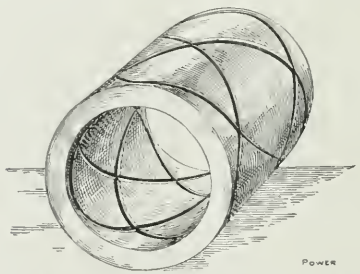
As the point is made of iron it will not give or become battered by the brick or jagged edges of the iron baffle-plates, and being wedge-shaped will, with light driving, force the baffles back and allow the tube to pass between them. When the tube is in place the bolt is slackened and the point removed from the tube. The largest diameter of the point is such as to pass through the hole in the header and to protect the end of the tube from being bent or battered. A patent has been applied for.

R. A. CULTRA.

Cambridge, Mass.

Revolving Sleeve for Bearings

Recently I made a sleeve bearing or bushing grooved on both inside and outside circumferences. These grooves are to distribute the lubricant equally on all the surface of the



REVOLVING GROOVED SLEEVE FOR BEARINGS

bearing. These grooves are all of uniform pitch and the work was done in a common lathe with a turning tool. It might be interesting to some and of benefit to others, who might want to use such a sleeve on close-fitting valve-stem bearings or on loose pulleys. On any high-speed bearing it is exceptionally good and ought to prevent or overcome serious friction troubles and losses.

THOMAS H. DELANEY.

New Bedford, Mass.

Why Does the Engine Rock?

Recently I visited an engine room in which there is a pair of engines which have been in operation for nearly 30 years. Both engines are now run condensing, and are connected to the same shaft, with cranks set on quarters or 90 deg. apart. A peculiarity of the outfit is the difference in the sizes of engines. One cylinder is 16 in. in diameter, and has a 36-in. stroke, while the other is 20 in. in diameter and has a 42-in. stroke.

Both are supplied from the same steam main and the pressure carried is 110 lb., the speed being 104 r.p.m., one governor controlling both sides by a cross-shaft. While the smaller engine is steady and shows no sign of rocking (a nickel standing on edge indefinitely on the steam-chest cover), the larger one has an end motion of at least ⅛ in. with each stroke. In the small cylinder the feet are part of the cylinder casting, on the larger one the feet are secured to the cylinder by bolts. These bolts have been repeatedly broken as a result of the rocking. The foundation is a brick and mortar affair with granite blocks under the cylinders, governor stand and pillow blocks, and shows that it is more or less saturated with oil. The average indicated load on the small engine is 85 hp., and for the 20-in. side, 180 hp.

Here we have one side of a unit with a stroke of 36 in. and the other with a stroke of 42 in., which makes a piston speed of 624 ft. for one and 728 ft. for the other when running at 104 r.p.m.

Both engines show evidences of at some time having received more water than was good for them, the crank disk on the small one being considerably out of true, due to a sprung shaft end, but this is the side that does not rock.

The master mechanic informed me that he had run a line through the cylinder of the larger engine, and that the crankpin center showed not more than a pencil line out from the head-end center to the crank center. Can readers tell why the other engine rocks?

H. R. Low.

Moosup, Conn.

Flywheel Bolts Stretch, Due to Centrifugal Force

The main driving belt on a 450-hp. cross-compound Corliss engine pulled apart when running under full load. The engineer who was about 100 ft. away, ran to the engine and shut the throttle valve, thus bringing the engine to a stop.

A splice was made in the belt, which was two-ply. About 90 per cent. of the break was through solid stock and about 10 per cent. through one portion of a lap. The engine was then started. After running at speed for a few moments the flywheel rim was discovered to be running out of true. After shutting down, examination showed that every bolt holding together the halves of the rim was sufficiently loose to allow the nuts to be turned by hand. These nuts were tightened, the hub bolts tested and found to be tight, and the engine run to speed. The flywheel rim then ran as true apparently as before the accident.

Nothing was discovered before or after the accident to indicate that the governor stop did not act to check the speed of the engine after the belt broke. The engineer concluded that the speed of the flywheel had begun to decrease before he shut off steam.

From this it appears that either the flywheel-rim bolts were loose before the belt broke, or that the flywheel-rim speed after the belt broke was sufficient to stretch the bolts, due to the centrifugal force of the rim.

With a 20-ft. diameter, cast-iron flywheel, it would be interesting to have the flywheel designer and the governor expert hand us a few figures, showing how long before the flywheel reaches the bursting speed, does the governor check the speed of the wheel, when full load is instantly thrown off.

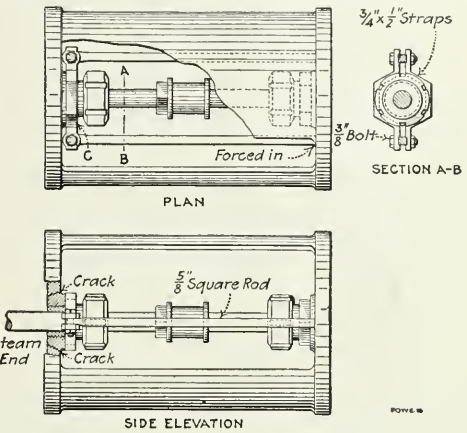
Forrest Allen.

Cleveland, Ohio.

Emergency Repair to Pump

Water-hammer in an air-bound suction pipe caused the metal around the stuffing-box of a 7x6¾x8-in. duplex service pump to break, as shown in the illustration. The pump was hurriedly repaired as follows:

Two lengths of ¾x½-in. flat-iron were bent into straps to go around the stuffing-box, back of the screw gland. The strap is shown at *C*. Two lengths of ⅝-in. square rod flattened at one end and drilled so as to receive the bolts that passed through the straps were then secured. These rods were a trifle longer than the distance between the straps and the water end of the pump, and were



How Cracked Head of Pump Was Repaired

hinged, being free to move in or out from the pump casing. After treating the break with red lead and when the two ⅝-in. rods were swung in and driven against the water end of the pump, the break was closed so tightly that no leakage whatever occurred. The pump ran in this way for a long time until a new cylinder was obtained.

John Mc A. Howden.

Melbourne, Australia.

Detector for Locating Knocks and Leaks

A convenient means of detecting the flow of steam through defective steam traps is by the use of an old telephone receiver. The wires are removed and a ¼-in. brass or steel rod about 6 in. long is fastened to the end of the U-shaped magnet.

To detect the flow of steam through a trap, place the rod against the outlet pipe and the receiver to the ear. By this means I recently found six traps discharging steam continuously. The flow of the steam could not

be heard without the telephone receiver, owing to the noise of the surrounding machinery.

This device also locates knocks in an engine.

Cleveland, Ohio. J. E. WASHBURN.

Clearing Plugged Blowoff Pipes

Where a number of boilers are each connected to a common blowoff main or trunk pipe by short leads from the mud drum or shell, and one of the leads becomes plugged, the obstruction may be removed as follows:

Reduce the pressure in the boiler having the affected lead to about 15 or 20 lb. below that carried by the other boilers. Now close the valve in the trunk line at the outlet end, and open the blowoff valve in the plugged lead. Next open the blowoff valve of one of the boilers carrying the higher pressure. The difference of pressure on each side of the obstruction will tend to break it up and clear the line. After being broken it will usually pass out when the blowoff valve is again opened.

Fall River, Mass. LUKE MARIER.

Automatic Pump Control

While engaged in installing machinery in a hydro-electric plant the writer's attention was drawn to a novel device in connection with the steam-heating system of the plant. The power house was built to permit the electrical machinery being housed well above the high flood-water

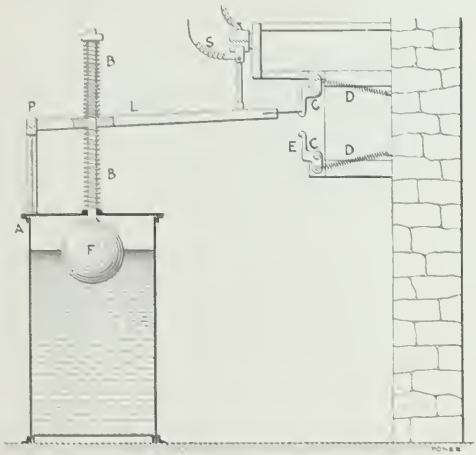


FIG. 1. FLOAT AND CONTACTS

mark, which necessitated the vertical-shaft type of turbines and a height between the basement and main floor of about 30 ft.

The heating boiler was located upon the upper floor, and all drainage of condensed steam from the heating system was returned to the boiler by a motor-driven plunger pump. The drainage was conveyed to a tank from which led the pump suction, and the capacity of the pump was such that the returns could be handled in about one-third the time it took to accumulate a tank full of water. This made an automatic stopping and starting device for the pump desirable.

The chief operator evolved the following scheme, which has now been working satisfactorily for several years: Re-

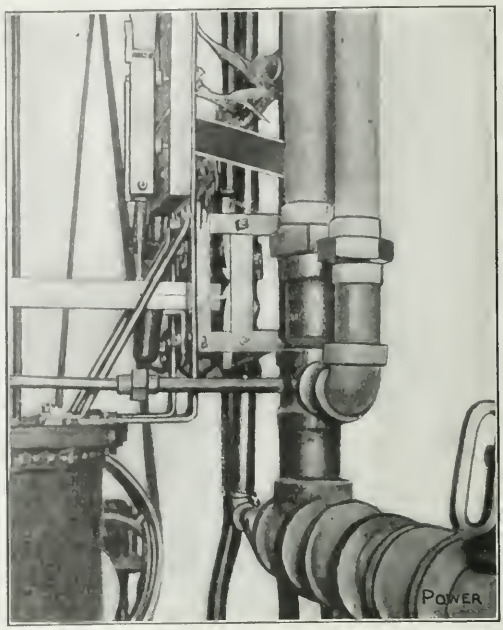


FIG. 2. GENERAL VIEW OF DEVICE

ferring to Fig. 1, *A* is the receiving tank, containing a float *F*, which as the water rises and falls actuates a lever *L*, swinging about the fulcrum *P*. This lever carries one-half of a switch *S* which controls the motor. Two latches *E* swing about the fulcrums *C*. These hold the switch in "on" or "off" position, until the buoyancy of the float when the tank is filling, or its weight when emptying, sufficiently compresses the springs *BB* to overcome the slight friction of the latches on the lever; the switch is thus thrown in or out decisively, and the circuit is made or broken. Two light adjustable springs *DD* suffice to hold the latches lightly in place and help to render the device sensitive. The device was made by Ira Johnson, of Sioux Falls, South Dakota.

Keokuk, Iowa. H. B. MCDERMID.

Leaky Tubes in Vertical Submerged Tubular Boiler

I have had considerable trouble with leaky tubes in vertical submerged tubular boilers used on steam shovels. After many times retubing and rolling the tubes will not remain tight more than two weeks. The tube sheet has always been thoroughly freed of all foreign matter before retubing. We tried $\frac{3}{32}$-in. copper ferrules in the firebox end of the tubes with little improvement. Cleaning boilers once a month, the average scale deposit on the tube sheet in 2400 hr. operation amounts to $\frac{1}{4}$ in. thickness. I should like to have readers of POWER suggest the probable cause and advise a remedy.

Covington, Ky. F. J. KRAMER.

QUESTIONS BEFORE THE HOUSE

Aftercoolers and Separators

The note by E. R. Pearce on "Air-Receiver Explosions," in the Apr. 29 issue, in which he suggests that the air should pass through oil separators, represents good practice, as far as it goes. I would advocate the use of an aftercooler for the air to pass through first, and then a separator. Both of these devices may be said to cost nothing to operate, unless the small quantity of water passed through the aftercooler is to be charged. The installation cost may be regarded as a paying investment in practically every case. The aftercooler will somewhat reduce the volume of air to be conveyed through the piping, and it will condense the surplus moisture in the air, so that it can be abstracted by the separator, as well as the oil. It will also keep the temperature of the air so low that spontaneous ignition in the receiver and piping will be practically impossible. Both aftercooler and separator are requisite for either of them to completely accomplish its work. The aftercooler will condense the moisture, but will not abstract much of it, and the separator will not abstract the moisture until it has been released by the cooling of the air. The functions of aftercooling and separating might be combined in a single device, but it does not seem to have been done.

It may be worth while to note that the too familiar air-receiver ignitions and explosions are impossible when the air is compressed by the Taylor hydraulic compressor, the Humphrey pump, or a centrifugal or turbo-compressor, because none of these put any oil into the air. For ordinary working pressures, if two-stage compression is employed, with an aftercooler and separator, these precautions may be considered to guarantee immunity. With a rapidly working single-stage compressor delivering the air at the same pressure, without aftercooler or separator, and with an engineer dispensing oil liberally, the guarantee would be reversed, and it would only be a question of time as to when something would happen.

FRANK RICHARDS.

New York City.

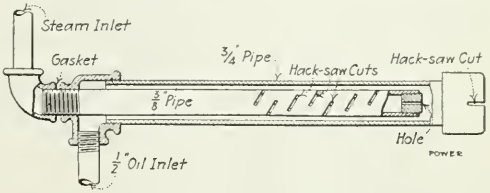
Home-Made Oil Burner

There are many patented oil burners and hundreds more that are not patented and every engineer in this part of the country has ideas of his own as to what constitutes a good burner. Following are directions for making a burner that gives very good results.

Get a ¾x⅜x½-in. tee, 12 in. of ⅜-in. pipe, 14 in. of ¾-in. pipe, one ¾-in. cap and one ⅜-in. elbow. Thread the ⅜-in. pipe on one end and plug the other end. With a hacksaw cut four, six or eight cuts diagonally across the pipe, the number of cuts being governed by the amount of work required of the burner. Now drill a small hole in the end of the plug like a miniature nozzle, dress the pipe over the saw cuts with a file and if any rough cuts have been made, peen them even to make a flat jet of steam from each cut strike the oil. Screw this pipe into the tee through the ¾-in. end and let it come through far enough to screw on the ⅜-in. elbow. Now screw the ¾-in. pipe into the tee outside the ⅜-in. pipe and get the ⅜-in. pipe in the center of the larger one.

Cut an opening in the ¾-in. cap with a saw, the size of the opening to be governed by the amount of fire needed. For a small boiler, a coarse saw cut is sufficient with four cuts in the mixer, for a large boiler make more cuts in the mixer and a larger opening in the cap. Use a needle valve on the oil-admission pipe and let the oil to the burner under 40 or 50 lb. pressure and at about 140 deg. F.

Insert the burner through the fire-doors about the center of the firebox and do not let the blaze strike the boiler. Keep a bright incandescent fire by giving the proper amount of steam and oil and keep the stack damper as nearly closed as possible. Keep the ashpit dampers 4 to



DETAILS OF OIL BURNER

6 in. open, just so quite a draft of air can be felt going into the pit.

An evaporation of 13.8 lb. of water to 1 lb. of oil has been attained with installations equipped with this burner.

J. E. PELTON.

Portland, Ore.

Algae in Water

Noting the inquiry in POWER for May 6, 1913, as to killing algae in water, the usually accepted method is to treat the water with copper sulphate, only about one part of which is required to sterilize 4,000,000 to 5,000,000 parts of water. Water so treated seems to be innocuous as far as drinking is concerned, or for laundry and similar industrial purposes. It will not do for irrigation, as it kills vegetation, just as it does the algae.

For boiler purposes, I do not know how it would be, but I saw some water carrying several hundredths of a per cent. of copper sulphate once used in several water-tube boilers with great profit to the tube makers. The iron of the boiler tubes cemented out the copper and then let go. Pending reports from a reader who has used copper-sulphate treated water in boilers, it might be well to treat the water in turn to get rid of copper sulphate; lime and soda-ash treatment should be effective.

DONALD M. LIDDELL.

Elizabeth, N. J.

Pressure in Standpipe

On page 723 of the May 20 issue under "Inquiries of General Interest," is the problem of the vacuum gages on the closed standpipe.

The diagram given shows the absolute pressures all right, but vacuum gages would read difference of pressure below atmosphere and the text distinctly says, "this would be the reading ——," etc. This I fear is misleading and gives the wrong idea, for I had to think it over some to get it straight.

S. B. Redfield.

Phillipsburg, N. J.

[It is customary in scientific computations, to avoid confusion, to use absolute pressures, which was our reason for so doing in explaining the gage problem. Gages are made which read that way, but commercial vacuum gages generally read as our critic indicates, i.e., in inches of mercury or pounds per square inch below atmospheric pressure. The following table gives the readings in all the different ways:

Gage	Pressure Absolute Ft. Water	Lb.	In. Mer.	Vacuum below Atmosphere Ft. Water	Lb.	In. Mer.
First Condition						
A	19	8 23	16.78	15	6.5	13 25
B	24	10.39	21.19	10	4.33	8.83
C	29	12.56	25.61	5	2.17	4 42
Second Condition						
A	24	10.39	21 19	10	4.33	8.83
B	24	10 39	21.19	10	4 33	8 83
C	29	12.56	25.61	5	2 17	4.42

—Editor.]

Water-Tube Versus Fire-Tube Boilers

In the May 6 issue, F. W. Dean deals some severe blows to the water-tube boiler as a steam generator for textile mill plants. He also mentions two disadvantages in using them, namely: They are more expensive to operate and they are more dangerous.

In regard to the cost of operation, I find that out of 15 tests each on water-tube and return-tubular boilers, the best record for evaporation on any of the return-tubular boilers was exceeded in several instances by the water-tube type. These tests were made under good conditions, but let us consider the average conditions under which textile mill plants may be run, for the boilers are not always kept up in the best condition and especially is this so if the feed water is of poor quality.

In any type of fire-tube boiler using water containing scale in solution, when the scale has accumulated on the surfaces of the tubes it is difficult to get at it except on the tubes that are nearest the point where a man can get in to work. In the large vertical boiler there are no manholes so that everything must be done from the handholes, and any engineer knows how difficult this is when the scale has gathered in the central part some distance above the lower tube sheet.

In a water-tube boiler of the horizontal-drum type with inclined tubes, every part of the water surface can be seen, so that it can be carefully examined and is accessible for cleaning. Thus when the water-tube boiler is finished it is known with certainty that it is in good shape. The extra labor of taking off and putting on handhole covers is well repaid by the higher rate of evaporation due to the absence of scale. In the fire-tube type it is largely guesswork as to the degree of cleanliness attained.

As to the accumulation of soot, the fire-tube can be allowed to run so long that it will be plugged solid and the gases cannot get through. Such a condition could not prevail in a water-tube boiler, for after the soot had accumulated to a certain depth on top of the tube it would begin to roll off. The under side of the tube will remain fairly free from soot indefinitely.

The amount of heating surface taken up by a set of vertical baffles is so little that it can safely be neglected when it is considered that the water-tube boiler has superior steaming qualities. The side openings in some boilers can be kept as tight as the back arch connection on return-tubular boilers, and one prominent make of boiler does not have these openings at all. In the vertical fire-tube boiler with the furnace all enclosed by water surface the combustion is not as good as in the brick-lined furnaces which retain the heat and do not chill the gases.

In regard to the number of accidents, Mr. Dean would probably find extenuating circumstances in most of the explosions. There are many types of water-tube boilers on the market and it is possible that some of them are not all that they should be, but there are some that have had years of hard service in all kinds of plants and these should be used as guides when a comparison is made with the return-tubular boiler.

The statement is also made that in the water-tube boiler the tubes are expanded into the drums. This is not true in all cases. In the Stirling boiler the tubes are expanded into the drums but the sheet is thick so that it can easily stand the strain. The expansion is compensated for by the tubes. In the Babcock & Wilcox boiler there are nipples expanded into a throat sheet which has unusual strength. The long service of some of these boilers has not disclosed a weakness in that feature of their construction.

In the water-tube boiler there is no uncertainty about the condition of the blowoff pipe, for it is outside of the setting instead of in the direct heat of the gases. The shells of water-tube boilers are up high, away from the hottest gases, so that they are not under excessive strain, and by reason of their convex heads and small diameter they need no staying. The plates are thinner and in the best makes they are made up with butt joints.

The tubes have the hardest service, but when they are worn out and a new set becomes necessary, the boiler is nearly as good as ever, for it is capable of withstanding the original pressure. In the return-tubular boiler after the shell has deteriorated the pressure must be gradually reduced until the boiler is discarded.

Mr. Dean favors the use of large units of 400 or 500 hp.; but there are few if any shell boilers that will develop that power at their normal rating while such sizes are common among water-tube boilers. To raise the horsepower of the shell boiler it is necessary to increase the diameter of the shell, while with the water-tube type more tubes and more drums can be added, and this does not affect the factor of safety at all.

It is my opinion that any textile mill can get as good, and in most cases better, service from the water-tube boiler than from any other type.

East Dedham, Mass. G. H. Kimball.

INQUIRIES OF GENERAL INTEREST

Heated Eccentric—If an eccentric and strap should run hot what should be done to fix them so as to run again?

H. L. R.

The eccentric halves should be parted and shims inserted.

Amount of Compression—Should a tandem-compound condensing engine be given as much compression as a cross-compound condensing engine?

E. P.

For smooth running a tandem-compound condensing engine should be given compression the same as a simple noncondensing engine; but in cross-compound condensing engines only enough compression is given to distribute the steam and operate the valve properly.

Pumping Height—To what height can a pump force water if the steam cylinder is 8 in. in diameter, the water cylinder 5 in. in diameter and the steam pressure 80 lb.?

H. L. R.

Neglecting friction the pump would exert

$$\frac{8 \times 8}{5 \times 5} = \frac{64}{25} = 2.56$$

times as much pressure per square inch in the water cylinder as would be exerted on the steam piston. Therefore, if the steam pressure is 80 lb. per sq.in. the pressure developed in the water cylinder might be

$$2.56 \times 80 = 204.80 \text{ lb. per sq.in.}$$

As 1 lb. pressure of water is equivalent to the pressure due to a head of 2.309 ft., then 204.80 lb. per sq.in. in the water cylinder of the pump would raise the water

$$204.80 \times 2.309 = 472.88 \text{ ft.}$$

Hammering in Pump Discharge—How can water or air hammering in the discharge pipe of a cold-water pump be stopped?

C. G. O.

Usually by connecting an air chamber on the line near the pump. This should have a volume of at least three times that of the water cylinder of the pump. The air chamber may be an ordinary pump air chamber, or may be made of a piece of large pipe set up vertically. The connection of the air chamber to the main discharge pipe should be the same size as the latter, and should have a stop valve. The air chamber should have a pet-cock on top and one near the bottom for testing whether there is any air cushion present. Any time it is found to have disappeared the main stop valve should be closed, the lower pet-cock opened for draining the air chamber and the upper air cock opened to admit air.

Piston-Rod Displacement Allowance—What allowance or correction is usually made for the volume of the piston rod in the crank side of the cylinder of a steam engine?

E. P.

There is no need to make any allowance for the cylinder space taken up by the piston rod, nor to take account of the piston-rod's reduction of the effective area on the crank side of the piston, for piston rods usually are only one-sixth the diameter of the piston This means that they reduce the piston area only $^1/_{36}$, which is less than 3 per cent., and for all ordinary considerations of steam distribution the space taken up by the piston rod may be neglected. On very large engines when the size of rods is considerable, allowance is usually made by causing a higher mean effective pressure on the piston-rod side so as to obtain equal power in both ends of the cylinder. This is accomplished by adjusting the valve gear so as to obtain a later cutoff on the crank end or an earlier one on the head end.

Compound Engine Cylinder Proportions—What are the right proportions for the cylinders of compound, triple-expansion and quadruple-expansion engines?

H. L. R.

Authorities differ as to the best proportions for the volumes of the high- and low-pressure cylinders of a compound-engine, varying from 1:3 to 1:5. In triple-expansion engines and quadruple-expansion engines the same is true. A common rule for a triple-expansion engine is to design the low-pressure large enough to furnish the entire power required at the mean pressure due to the initial pressure and the expansion ratio given. Then this cylinder is given only pressure enough to perform one-third of the work and the other cylinders are so proportioned as to divide the other two-thirds between them. In quadruple-expansion engines the ratios of cylinders for very best economy vary for different initial pressures and vacuums so that different designers will naturally vary in their opinions with respect to proportions. Quadruple-expansion engines intended to be operated at a pressure of 180 lb. per sq.in. are given cylinder ratios of about 1: 2: 4: 8.

Determining Chimney Size—What rule may be used to find the size of chimney required for a given horsepower capacity of boilers?

J. P.

If the boiler horsepower is given and the chimney height (H) assumed, the effective area (E), in square feet, may be found by the formula

$$E = \frac{0.3 \text{ Hp.}}{\sqrt{H}}$$

For round chimneys the actual diameter should be the diameter of the effective area plus 4 in. and for square chimneys each side should be the side of a square of an area equal to the effective area (i.e., the square root of the effective area) plus 4 in.

As an example, suppose it is required to find the diameter of a round stack, 81 ft. high, which would be suitable for 100 hp. Substituting the values,

$$E = \frac{(0.3 \times 100)}{\sqrt{81}} = 3.33 \text{ sq.ft.}$$

or

$$3.33 \times 144 = 479.52 \text{ sq.in.}$$

which is the area of a circle of about 24¾ in. in diameter. Therefore, the actual diameter should be

$$24.75 + 4 = 28.75 \text{ in.}$$

Suction-Pipe Flow—What is the maximum amount of water in U. S. gallons per minute, that can be raised by a vacuum at sea level through a 1¼-in. pipe?

A. P. S.

This will depend on the roughness and length of the pipe and the perfection of the vacuum. With a perfect vacuum a rate of flow would be created equal to one corresponding to a head of 34 ft., but an ordinary good pump with tight connections could not be depended upon to exceed an equivalent of about 25 ft. of head.

The flow of water taking place under various heads and for various lengths of wrought-iron pipe is treated of in an article "Flow of Water in Pipes and Flumes," in "Power," Nov. 10, 1908, pages 775 to 780.

From diagrams in this article, assuming the suction pipe to be 10 ft. long, it may be found that for a total head of 34 ft. the pipe friction would be about

$$\frac{200}{100} \times 10 = 20 \text{ ft. loss of head}$$

Velocity head = 10 ft.

and

Entrance head = 4 ft.

Total = 34 ft. head

and the discharge about 75 gal. per min.

With a vacuum equal to about 25 ft., the pipe friction would be about

$$\frac{60}{100} \times 10 = 16 \text{ ft. loss of head}$$

Velocity head = 6 ft. and
Entrance head = 3 ft.

Total = 25-ft. head

and the discharge would be about 65 gal. per min.

ENGINEERS' STUDY COURSE

Making a Flue-Gas Analysis—Part III

Loading Apparatus

The correct amount of chemical must be put into each pipette or otherwise the apparatus will not work well. Remove the gooseneck from the rear leg of the pipette and add the chemical through the glass funnel until the two legs are slightly more than half full. In order that the liquid may rise equally in both legs the stop cock in the front connection must be open and also the three-way cock *P* in the header (shown in Fig. 1, repeated from last lesson) must be open to the atmosphere. After you have filled one pipette *J*, for instance, tested it and found it to contain the proper quantity of liquid, it is an easy matter to get the other two correct simply by filling them to the same level.

To test whether pipette *J* contains the right quantity of liquid, fill the leveling bottle *I* about two-thirds full

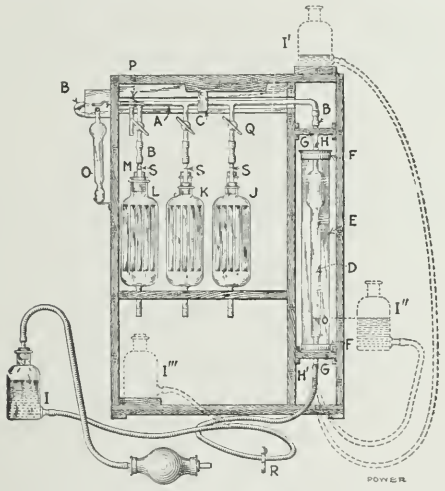


Fig. 1. Diagram for Assembling Orsat

of water, first closing the pinch cock *R*. See that all the glass cocks connecting with the header are closed except cock *Q*, which must remain open. Now, raise the leveling bottle and place it on top of the cabinet as at *I'*. Then, press the buttons of the pinch cock *R* until the water begins to rise in the burette. This places the air trapped above the water in the burette and in the header under a slight pressure and as the stop cock *Q* is open this pressure is communicated to the front leg of the pipette *J*, driving the liquid down in this leg and up in the back leg. By regulating the pressure of your fingers on the pinch cock *R* you can control the flow very nicely. If the pipette contains the correct amount of liquid, by the time the liquid has gone down in the front leg to the point where the body part begins to narrow into the bottom-connecting tube, the liquid in the back leg will have risen to the point where the body part begins to narrow into the neck at the top.

If too much liquid has been put into the pipette, the back leg will be full or overflowing before the front leg has been emptied to the point mentioned in the preceding paragraph, and some of the liquid will have to be removed. If not enough liquid has been put in, air will force its way through the bottom connection and bubble up through the liquid in the back leg. To prevent this, more liquid must be added.

Emptying Pipettes

After the apparatus has been used for some time, the chemicals become weak and must be renewed. A convenient way of emptying a pipette is to fill a short length of rubber tubing (about 2 ft. long) with water, and while holding your finger over one end, to prevent the water from running out, put the other end into the back leg of the pipette. Then, lower the free end into a sink or basin so that this end is somewhat below the other and release your finger, when the liquid will all siphon out of the pipette.

Preparing for an Analysis

After all three pipettes have been properly filled and tested the apparatus is almost ready for making analyses. Before it is quite ready, however, the liquid in each pipette must be drawn up into the front leg until this leg is full to the fine black ring, which will be found around the neck at *S*.

To do this in the case of pipette *J*, notice whether the water level in the burette *D* is near the top. If it is not, close all the header-connection cocks except the three-way cock *P*, which must be open. Then, raise the leveling bottle to *I'* and allow the water level to rise in the burette by opening the pinch cock *R*. When the water level in the burette is right, close the three-way cock and open stop-cock *Q*. Lower the leveling bottle to the table and by releasing pinch cock *R* allow the water in the burette to run back into the bottle; while doing do, watch the liquid rise in the front leg of *J*. When this is near the top, proceed very slowly and carefully as the necks *M* (made of what is known as capillary tubing) have a very fine bore, and if you allow the liquid to rise too rapidly when near the top, there is considerable danger that it will shoot up into the header and over into the burette before you can check it. While this will do no harm when practicing with water, it is undesirable when dealing with the chemicals, as it makes the water in the burette more or less capable of absorbing the flue gases, thus causing error, and it reduces the quantity of liquid in the pipette so that trouble may arise in this direction also.

The proceeding for bringing the liquid in pipettes *K* and *L* up to the mark is exactly the same as for pipette

, only, while doing so, it is advisable to remove the goose-ecks with the rubber bags attached, from the mouth of he back legs, for unless there happens to be enough air n these bags, a vacuum may be formed over the liquid n the back leg, thereby preventing it from coming fully ip to the mark in the front leg as it should. As soon as the liquid has been brought up to the mark, replace he goosenecks and rubber bags to prevent further con-act with the outside air. When dealing with the chem-icals, the air that it trapped in the back leg of K and L will lose its oxygen, and, hence, shrink in volume so that a slight vacuum will be formed. When this noticeably interferes with the operation of the apparatus, remove the gooseneck for an instant to let in a little more air. Be sure to do this, however, when the liquid is up to the mark in the front leg or when the gas bag is perfectly flat or empty, as otherwise, instead of letting more air into the system, you will really let some out and cause a worse vacuum than ever.

A better way to avoid trouble from the formation of a vacuum is to force a little excess air into the bag by blowing into it with your mouth, then, pinching the neck to hold the air in until the connection is made. It is well to take precaution, however, when doing this, and be sure that there is none of the chemical on the end you put to your lips, as otherwise you may burn yourself.

With the liquid in all pipettes properly adjusted, an analysis can now be made. That is, we can go through the motions of making an analysis. Later, when more practice has been gained, we will load with the proper chemicals and after making suitable arrangements for obtaining a sample of the flue gases, we will be prepared for actual work.

Size of Sample

For the present, assume that the filter O is connected with the supply of gas. Our sample will consist of 100 c.c. of flue gas at atmospheric pressure and at the temperature of the ordinary room air.

At its lower part, where all our readings will be taken, the burette is graduated in cubic centimeters with a subdivision for each 0.2 of a cubic centimeter. Thus, the figures of the scale read direct in per cents. and decimal fractions of a per cent.

A cubic centimeter is another French or metric unit employed because of its great convenience, like the gram, decigram and milligram in our proximate coal analysis. The metric units of length, corresponding with inches, feet and yards, are the centimeter, decimeter and meter. Consequently, the units of volume are the cubic centimeter, cubic decimeter and cubic meter. Do not fall into the mistake, however, of assuming that 100 c.c. equals one cubic meter, for they do not—no more than 12 cu.in. equal one cubic foot. At the bottom of the scale on the Orsat burette you will find the letters c.c., which is the standard abbreviation for cubic centimeter.

Effect of Temperature and Pressure

You may have noticed that I specified that our gas sample was to be at a certain pressure and temperature. This is because the volume of a gas is greatly influenced by changes in pressure and temperature. Hence, we must be careful to have conditions uniform throughout an analysis, or error will result. It is advisable for best results to locate the apparatus where no drafts will blow on it and where the temperature of the air does not change rapidly.

To illustrate how important an influence temperature and pressure have, two simple experiments can be made with your Orsat.

To show the effects of change in temperature, locate the apparatus in a warm spot and allow it to remain there for about an hour, until the glass work and the water come up to the temperature of the air. Then, with all cocks closed except P, which must be open, slowly raise or lower the leveling bottle, using the side of the cabinet as a guide, until the water level in the burette D is exactly on the zero mark, while at the same time the water level in the bottle is at the same height as the water level in the burette, as shown by the position of the bottle at I''. Then, using care not to change the level of the bottle, close cock P. To make sure that no mistake has been made while closing the cock P, check the water levels once more by noting whether both are at the level of the zero mark. If not, and if they cannot be brought right by a slight raising or lowering of the bottle, open the cock P and start all over again.

Having thus succeeded in getting the correct quantity of warm air into the burette, place the leveling bottle in its cleat within the cabinet at I''' and shift the apparatus to some spot where the temperature is 10 or 15 deg. cooler. After about an hour's time, test the water level again (without opening cock P) by slowly raising and lowering the leveling bottle at the side of the cabinet until the level in the bottle is the same as the level in the burette. This new level will be considerably above the zero mark, showing that the reduction in temperature caused the volume of the air in the burette to shrink. A reduction in temperature of 10 deg. means a reduction in volume of about 1.8 per cent.

To show the effect of change in pressure, open cock P and by raising or lowering the leveling bottle, draw in enough air to bring the water level to about the 10 per cent. mark. Close cock P and make an accurate reading by raising or lowering the bottle until the water level is the same in the bottle and in the burette. Now, if you raise the bottle, say, to position I', the water level in the burette will rise almost to the 14 per cent. mark. This shows that the tendency of the water in the bottle to flow into the burette and seek its own level has put an increase of pressure on the air trapped in the burette and, hence, has reduced its volume by compression.

Manipulation of Three-Way Cock

Thus far, I have said nothing about the manipulation of the three-way cock P. Its correct manipulation is very important when making an actual analysis, and as a poor understanding of how it should be handled would undoubtedly lead to confusion and inaccuracy in results, it is worth devoting a paragraph at this point to this important part of the machine.

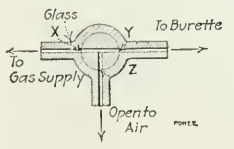


Fig. 4. Diagram of Three-Way Cock

Fig. 4 is a diagram of the three-way cock connection. The straight-run passage XY is parallel with the handle

of the cock and the branch connection Z is on the inside as a dark dot found on the handle. In the position shown in Fig. 4 (in which position the handle would be horizontal and the dot would be facing down) the gas supply, the outside air and the burette, would all be connected.

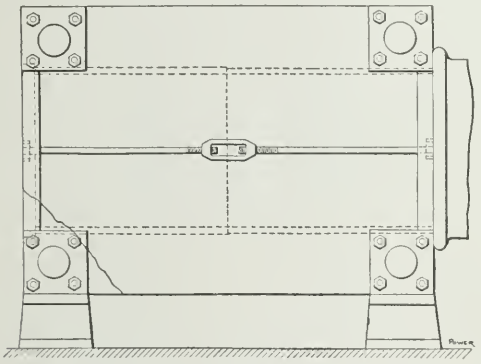
In the reverse position (with handle horizontal and dot facing up) only the gas supply and the burette would be connected. With the handle in a vertical position and the dot facing to the left the gas supply and the outside air would be connected. With the handle vertical and the dot to the right, the burette and the air would be connected. With the handle in any 45-deg. position no connections would be open. In the next lesson the instructions for setting up will be continued and the tests for oxygen, carbon monoxide and carbon dioxide explained.

⁂

Repairing a Broken Cylinder

By W. H. Wakeman

The cylinder of a Corliss engine was broken in some unknown way, near the head-end exhaust port, as shown by the irregular diagonal line. The internal diameter of this cylinder was 14 in., but the engine carried only a light load, hence it was practicable to repair the damage by inserting a cast-iron bushing 1 in. thick, thus reducing the diameter to 12 in. The stroke is 36 in.



How the Cracked Cylinder Was Repaired

In order to secure a true circle in the cylinder, it was rebored. The first half of the length was made larger than the remainder, as shown in the illustration, therefore, when the bushing was inserted it went in easily to this extent, but it was necessary to use much force to put it into the required position, as it was 0.004 in. larger than the cylinder. Near the outer end a raised shoulder ⅛ in. high and 1¾ in. long, was provided to hold the broken part in place. This was made a sliding fit in the cylinder, to avoid expanding the cracked portion. Screws were put through the cylinder into this bushing to hold it in place, but care was taken to avoid boring holes completely through the bushing.

A turn buckle was used on each side as illustrated, thus providing additional security against any possible movement of the bushing. While this was an expensive job, it cost less than a new cylinder, and the necessary shutdown of the works was comparatively short.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"Where am I going the Fourth? To work! Just like I do on all other holidays and Sundays. Get a day off? Yes, when they put eight days in a week. Say, kid, they tell me I ought to be glad to be living, and have a steady job. It's some steady, all right.

"I had a dandy vacation two months ago—when I was laid up with the rheumatism—for three weeks. What'cher got on your mind, bub? You thought a power-plant engineer was a human being; needed a rest like other folks? Not on your fragile existence! He just keeps going, and going, and going—till he reaches the scrap heap. Gee! Ain't you never known an engineer before?"

⁂

A refrigerating plant with a daily capacity of seven tons has been installed in the White House. It ought to help the President to turn a cold shoulder to the over-persistent office seeker. It's also a shop kink for the Secretary of State that might help him in keeping his grape-juice policy up (or down, if you drink) to the mark.

⁂

Nearly 800 degrees at Yale.—Headline.

Must have been a hot time at our college during commencement, son. In the parade they sang "Onward Christian Soldiers." Even when the mercury has shinned up to 100 deg. it requires considerable fortitude for us to chant "A Hot Time in the Old Town."

⁂

Going up! A young elevator "engineer" has had $200,000 wished on him by a grateful New York manufacturer of engineering materials. The elevator man once saved the life of this now deceased gentleman. Mrs. Engineer says that, if she has her way (and they generally do), they will settle down, put this neat little wad into real estate, "and raise a big family." We quote the lady's own words, and hope that her very laudable ambition will come true. P. S.—The proofreader says this is a dream. All right, it's a good one.

⁂

Speaking of big families, did you know that a fly lays 120 eggs four times each season between May 1 and Sept. 30? And the flies therefrom number.

9,134,843,744,256,000,000,000

Mebbe a few hid themselves on the count, but it's near enough to worry the bald-heads. And we're trying to swat this pest into a place some high forehead calls oblivion.

Having fixed the number, now it's up to some bally ass to ascertain their exact weight. In fawncy, we can hear some member of the Weight Committee at the coming Springfield convention declare. S-O-M-E W-E-I-G-H-T!

⁂

"RECHARGING A DRY BATTERY"

Unless your eye has already focused the clever picture below, you will probably conclude from the title that this much discussed subject has oozed over from the electrical department.

This is such an efficient way of recharging this particular type of dry battery that when we saw it in Brother Clarke's "Gas Review," we got his permission to reproduce it.

Successful Small Insolated Plant

SYNOPSIS—This plant, although small, displaced central-station service, making a saving of $2000 per year. The equipment is of standard type. The chief engineer has supervision of the entire mechanical equipment of the factory.

Motive power for the factory of Larned, Carter & Co., Detroit, Mich., was purchased from the central station for several years before John Gunn, the present chief engineer, took charge. By dint of much convincing reasoning and the use of cost figures, of which he was absolutely certain, he finally persuaded the owners to install electrical generating equipment. So skeptical were they, however, of the success of the venture, that the builder of the engine installed was forced to agree to take his pay out of the saving he predicted would result.

The power plant has been in operation for about two years, and the results obtained have been so satisfactory that the engine man was paid in full in less than a year.

The factory consists of two buildings, one of which is three stories high and 75x130 ft. in area, and the other, five stories high and 50x130 ft. Thirty-five motors, the majority of which are of 3- and 5-hp. capacity, and two elevator motors, one of 10 and one of 15 hp., furnish the power load, some fifteen hundred 16-cp. incandescent lamps furnish the lighting load. The current requirement is quite uniform, never falling below 90 or exceeding 100 kw. This and the fact that the plant is constantly maintained in the best possible condition and

Fig. 1. Boilers and Stokers

operated so as to yield the highest all-around economy accounts for the unusually good showing made.

Complete cost figures are not available, but the general summary is true that allowing 15 per cent. per year for depreciation, maintenance, insurance, etc., on the $12,000 invested for the extra equipment installed, the annual saving is about $2000.

Boilers and Stokers

Fig. 1 shows the boilers and stokers. The nearer one is a return-tubular, 60 in. by 14 ft. in size, having 64 tubes, 3½ in. in diameter, and rated at 90 hp. This boiler has been in since 1902, and before the power equipment was installed it was used for heating work only. The steam pressure then carried was 90 lb. gage. The

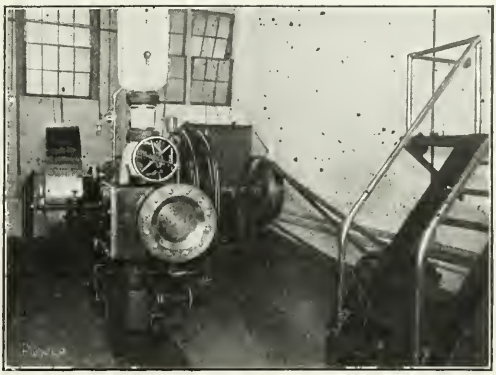


Fig. 2. Engine and Dynamo

pressure at present carried is 85 lb., gage, although 125 lb. is allowed by the insurance company. The farther boiler is a 125-hp. return-tubular, 72 in. by 14 ft. in size, having 86 tubes, 3½ in. in diameter. It has been in service the two years the generating equipment has been installed.

Each boiler is fitted with an under-feed stoker. As the generator is operated only from 7:15 a.m. to 4:30 p.m., and until 11:30 a.m. on Saturdays, but one shift is needed in the plant. The fireman gets down about 6:30 a.m. and starts the stoker-fan engine on whatever steam pressure the boilers have retained over night, and in a short while the working pressure is built up so that the generator can be started and take the load as soon as the 7:15 whistle blows. Shortly before stopping time, the fires are cleaned and put into good condition for banking and the stoker plunger is stopped. Thus, by the time the engine has been shut down the boilers have practically ceased making steam and are ready to be laid up for the night.

Forced draft for the stokers is furnished by a 32x10-in. steel-plate fan driven by an 18-hp. vertical engine, the speed of which is automatically regulated to suit the steam requirements by means of an automatic pressure valve. Each boiler has its own stack; the one for the small boiler is of brick, 75 ft. high and 24 in. square inside, and the one for the large boiler is of iron, 90 ft. high and 24 in. in diameter inside. Island Creek nut, pea and slack coal, mixed, costing $2.50 delivered, is used as fuel.

The feed water is heated in an 80-hp. open heater arranged with a bypass. Returns enter the heater direct from the exhaust-steam heating system during the winter season. An oil separator in the exhaust line removes a large percentage of the cylinder oil from the steam, so

PRINCIPAL EQUIPMENT OF LARNED, CARTER & CO.'S PLANT

No.	Equipment	Type	Purpose	Kw.	Volts	Cycles	Phase	Size	Hp.	Speed	Press. Lb.	Manufacturers
1	Boiler	Return tubular	Steam gen.					60″x14′	90		85	Gem City Boiler Co.
1								72″x14′	125		85	Wickes Boiler Co.
2	Stokers	Jones	Boiler furnace									Under Feed Stoker Co. of Americ
1	Heater	Open	Feed water							80		Harrison Safety Boiler Works
1	Separator	Oil	Exhaust									Austin Separator Co.
1		Steam	Line steam									
1	Pump	Duplex	Boiler feed					5½x3½x5″			85	Deane Steam Pump Co.
1	Engine	Simple	Main unit					17x18″		225	85	Skinner Engine Co.
1	Generator	A. C.	Main unit	150		60	3			225		
1		D. C.	Exciter	8	125							Fort Wayne Electric Works
1			Auxiliary	3½								
2	Blowers	Diamond	Tube									Diamond Power Specialty Co.

that but a very small quantity indeed finds its way to the boilers. The boiler-feed pump is a 5¼x3½x5 in. duplex, and is regulated by hand.

Generating Equipment

The generating equipment is shown in Fig. 2. A 17x18-in. simple engine, which runs at 225 r.p.m., is direct connected to a 150-kw. alternating-current dynamo, which generates 60-cycle, three-phase current at 220 volts. The 8-kw. exciter is belt driven from the larger pulley attached to the outboard end of the shaft. A second direct-current dynamo is belt driven from the smaller pulley. This machine has a capacity of 3½ kw., and is employed to furnish current for a number of ⅛-hp. motors for portable cloth-cutting machines.

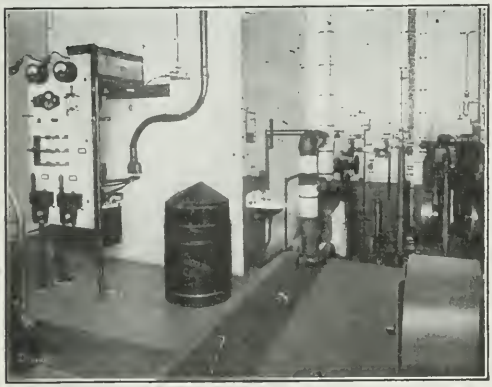


Fig. 3. Switchboard and Steam Auxiliaries

Steam is supplied to the main engine and the auxiliaries through a 6-in. header. The engine is equipped with a steam separator of ample capacity, as shown. The exhaust pipe drops straight down and makes connection below the floor level with the heating main, feed-water heater and the atmospheric exhaust stack.

The switchboard, the heater and the stoker fan and engine are shown in Fig. 3. The switchboard consists of one panel 2 ft. 6 in. wide by 5 ft. high. The generator and exciter rheostats are mounted at the top and rear of the board and adjusted by handwheels. A single voltmeter, ammeter and ground light is used, being connected with either phase, by a three-point switch. One feeder cable extends to each of the factory buildings and is controlled by a combination oil-break circuit-breaker and disconnecting switch. An emergency connection can be established with the central-station distribution system by means of a three-pole double-throw main switch mounted in the middle of the board.

All piping, including the boiler feed, exhaust steam, stoker and stoker engine, is controlled in the engine room

The engine is equipped with a self-contained oilin system, consisting of a receiving well, strainer and filte pump, and the necessary piping to the various bearing and other parts. Every two weeks the old oil is drawn o and 2 gal. of fresh oil supplied. The old oil is used i the factory for lubricating pulleys, shafting, etc. Th cylinder-oil consumption averages 9 gal. per month.

During the summer the boilers are cleaned once eve four or five weeks, and in the winter, every eight week

⁂

Neco Feed-Water Regulator

The main feature of this regulator is that it is designe to decrease the water level in a steam boiler when the loa increases and to increase the water level when the loa decreases. It is manufactured by the Northern Equi ment Co., 408 West Indiana St., Chicago, Ill.

The Neco regulator depends for its operation upon th admission of steam or water into the expansion tube, th steam flow being dependent upon the water level, *i.e.* whether it is above or below the connection to the upp end of the tube.

With the water below the center gage, steam flows the expansion tube, thereby expanding it with the he and forcing it against the short arm *OD* of the bel crank *DOE*. The arm *OE* in turn rises and, liftin the weighted toggle arm *F*, opens the feed valve.

The flow of water through the opened feed valve rais the level and the steam supply is cut off. The stea already in the tube condenses and the tube deprived the constant heat required to maintain it expanded, co tracts, thereby drawing back the arm *OD* and lowering t arm *OE*, which allows the weighted toggle arm *F* to for shut the feed valve by gravity.

To avoid a recurrent complete opening and a comple closing of the valve a toggle motion is used. The arc the point *H* is such that when the arm *F* is raised, t motion is at first slight and the valve is opened b slightly. Later, the speed of the motion increases as t point *H* moves upward in its arc.

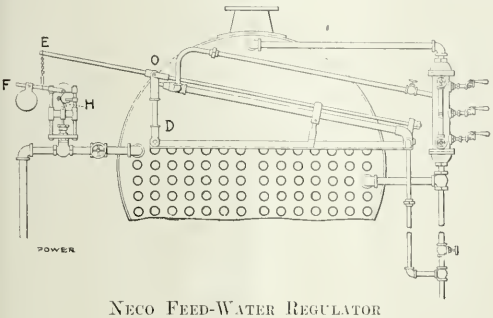
In reverse fashion, as the contracting tube allows t arm *F* to force the valve shut, the closing is at first rap and then so slow that before the contraction is comple and the valve entirely closed a fresh supply of steam the expansion tube has arrested the process of contracti In this way, by slowing down with the toggle, the acti of the regulator is made so gradual that with the wat above the second gage it is feeding somewhat less than t evaporation, and with the water level below the cent gage, it is feeding somewhat more than is being eva orated.

As shown diagrammatically, the regulator triangle placed so that the lower end of the expansion tube is the desired low-water limit, and the upper end of t

tube is placed so as to be opposite the highest water level desired. By merely changing the angle of the expansion tube, the variation in the height of the water level between no load and full load can be set at a few inches or a foot as desired, to suit local conditions. The triangle need not necessarily be placed in front of the boiler, as shown. It should, however, be placed as near the water column as possible and in such a position as will bring the ends of the expansion tube at the desired water levels.

The regulator is adjusted so that at normal load the control valve is open just wide enough to keep the water at the desired normal level, usually the second gage; the expansion tube is, therefore, half full of water at normal load.

Any unusual increase in the steam demand lowers the boiler pressure, which in turn lowers the temperature at which the water will boil, and due to the increased heat demanded, the water level will rise suddenly. This sudden rise of water in the expansion tube contracts a section of the latter and through the levers and toggle



Neco Feed-Water Regulator

motion reduces the valve opening sufficiently to decrease the water supply exactly at the moment when little or no cold water is desired. Then, because the boiling temperature has been lowered, a comparatively large amount of water is quickly evaporated to take care of the overload. The water level, being thus lowered, allows a little more steam to enter the expansion tube, and, through the action of the latter, opens the control valve wide enough to take care of the overload, but no more.

This action continues and the steaming capacity increases with every load increase until the safe allowable low limit of water is reached; at this point the expansion tube, being full of steam, reaches its maximum expansion and the control valve opens to its full area.

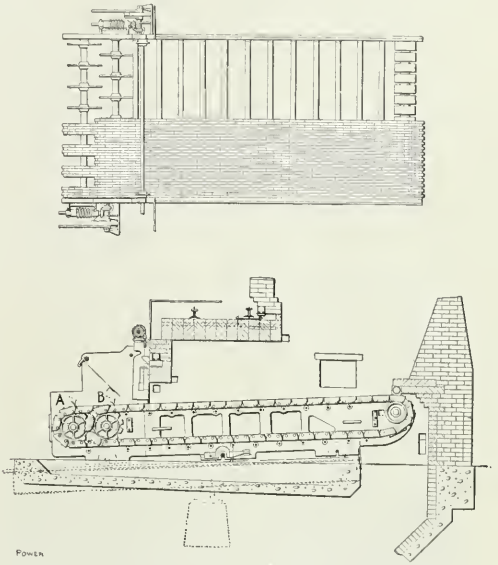
When the load suddenly becomes less, the action is reversed. Closing the draft causes the water level to drop suddenly. The control valve is opened wide and water fed into the boiler until a level is reached, at which point just enough water is fed to supply the evaporation—hence the rate of steaming is automatically retarded and the heat energy, which would otherwise be wasted in steam escaping through the pop valve, is used to heat the additional water.

The design of the regulators is such that full valve opening is secured only when the expansion tube is fully expanded, and the control valve can be shut only when the expansion tube is completely contracted. Full expansion occurs only when the tube is full of steam and it is impossible to secure this except when the water has receded to the lowest desired level. Also, complete contraction occurs only when the tube is full of water, and this can occur only when the high desired level has been reached.

Illinois "Type B" Chain-Grate Stoker

A chain-grate stoker, different in some respects from others, is illustrated herewith, and the principle on which the grate operates is described. Fig. 1 is a longitudinal section through the stoker and setting, and shows a new feature in arch construction, the novel feature of tilting the stoker for varying the discharge at the rear of the grate, and the means by which the "slicing" action of the grate is produced.

The grate is made up of two sets of strands of links *A* and *B*. Each strand is approximately 6 in. wide. The relative position of these strands is indicated by Fig. 2. Each set is operated by its own mechanism, as shown,



Plan and Elevation of Chain-Grate Stoker

which intermittently starts and stops its respective set of strands.

The drives are so arranged that, while, say, the longest strands are in motion, the shorter strands are at rest, then the shorter strands advance, and the longer strands remain stationary.

Since the two sets of strands move an equal distance each time they advance, and each remains stationary the same length of time, the coal is uniformly supplied across the width of the grate. This automatic and continual slicing prevents a crust forming over the top of the fuel bed, and an adequate supply of air can be introduced and brought in contact with the fuel.

Any kind of coal can be economically burned by regulating the periodic time for starting and stopping the strands, and thereby increasing or decreasing the "slicing" effect.

This stoker is manufactured by the Illinois Stoker Co. Alton, Ill.

Mesta Single-Stage Air Pump

A new design of reciprocating air pump has been placed on the market by the Mesta Machine Co., of Pittsburgh, Penn. A section of the cylinder and an elevation is shown in Fig. 1. The steam cylinder, which is arranged

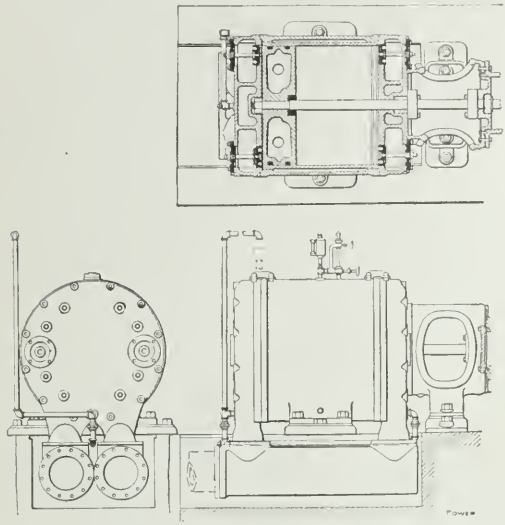


FIG. 1. SECTION AND ELEVATION OF AIR CYLINDER

in tandem and provided with a Meyer valve gear, is omitted. The feature of the air cylinder is the automatic multiported valves of the plate type, which follow in design the Iversen patent. The construction of the valve is shown in Fig. 2. A thin annular steel plate is

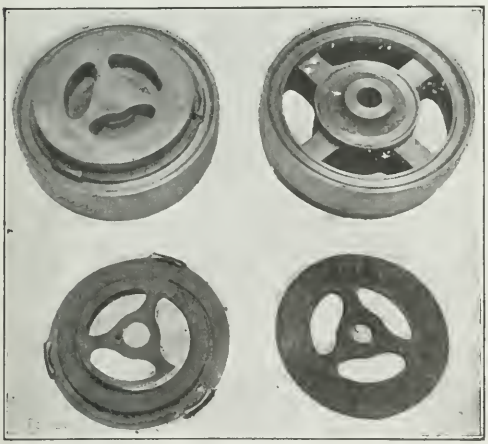


FIG. 2. PARTS OF AIR VALVE

guided without friction by a volute spring. The upper view at the right shows the seat which is bolted to a plate attached to the cylinder head. The four ports in the seat are visible, and in the view at the left the plate is shown in place. The movement of this plate is controlled by the pressure or suction in the cylinder, the spring furnishing the small force necessary to start the closing motion of the valve at the right time. Reference to Fig. 1 will show the location of the valves in the cylinder. Two discharge valves are located on one side, and two suction valves on the other. Due to the construction of the valves the clearance space is very small.

One of these pumps was set up in the works of the company and subjected to a thorough test by Prof. W. Trinks, of the Carnegie Institute of Technology. A tank was arranged in the suction line to convert the pulsating suction of the pump into a steady flow, so that the actual quantity of air taken into the pump could be measured by a standard nozzle. Another nozzle was provided at the side of the tank for admitting vapor to duplicate conditions existing in condenser practice. The steam passing through the engine was condensed at atmospheric pressure in a surface condenser located in the pit under the flywheel, and the condensation was measured in barrels.

When it came to plotting the results of the test, it was decided that it was not feasible to give the steam

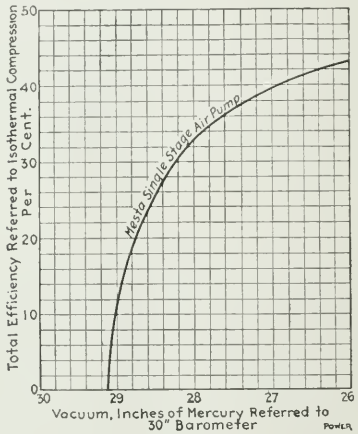


FIG. 3. EFFICIENCY CURVE OF PUMP

consumption per cubic foot of air pumped, as the steam consumption must necessarily vary with the vacuum, the efficiency of the air pump and the efficiency of the prime mover. To separate the two efficiencies, the ratio of the ideal work required for isothermal compression divided by actual work (including all friction work of the engine) required, was plotted against the vacuum referred to a 30-in. barometer. Reference to the curve will show that the pump dropped off rapidly in efficiency above 29 in. of vacuum, and becomes useless for vacuums higher than 29.1 in. Below 29 in. of vacuum, however, the pump rapidly increases in efficiency, and at 26 in. shows remarkably high results. For high vacuums a compound air pump is now being built and test results will soon be available.

Among the cities which are making practical efforts to abate the smoke nuisance are Baltimore, Boston, Buffalo, Chicago, Cincinnati, Cleveland, Denver, Detroit, Indianapolis, Jersey City, Kansas City, Los Angeles, Louisville, Milwaukee, Minneapolis, Newark, N. J., New Orleans, New York, Philadelphia, Pittsburgh, Portland, Ore., Providence, Rochester, San Francisco, Seattle, St. Louis, St. Paul and Washington.

Coke vs. Oil as Steamship Fuel

The following report, published in the Vancouver *Province,* on the comparative costs of coal and oil as fuel on two of the C. P. R. British Columbia Coast Service steamships, is of interest, in view of the number of vessels which have recently been built to consume liquid fuel, or have been changed so that either of the two fuels may be used. The costs of coal and oil for the steamship "Princess Victoria" are given herewith:

COAL

	Per Day
100 tons at $4.50	$450.00
9 firemen at $55 a month each	16.50
9 trimmers at $45 a month each	13.50
Food for 18 men	7.56
Total	$487.56

OIL

344.17 barrels, at 90c	$314.25
6 firemen	11.10
Food for 6 men	2.52
Total	$327.87

The costs for the Princess Charlotte, a larger vessel and of greater horsepower, are as follows:

COAL

100 tons at $4.50	$450.00
13 firemen at $55 a month each	23.80
10 trimmers at $45 a month each	15.00
Food for 23 men	9.56
Total	$498.36

OIL

344.17 barrels at 90c	$314.25
6 firemen	11.10
Food for 6 men	2.52
Total	$327.87

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Graphite in Boilers

POWER put it squarely up to manufacturers of boiler graphite to show that their products were not injurious to boilers. This came about after a number of letters had been printed from users all endorsing its scale-removing properties. Then appeared the statement of a naval engineer in a convention paper that it accelerated corrosion. The following is a report on this matter made for the United States Graphite Co. by the Pittsburgh Testing Laboratory:

United States Graphite Co.,
Saginaw, Michigan.

Dear Sirs—

Referring to your letter of Feb. 13, 1913, and subsequent communications on the subject of the influence of graphite suspended in water upon the rate of corrosion of steel with which the water is in contact, and referring particularly to the opinion expressed by Lieutenant-Commander Frank Lyon, U. S. N., in the "Journal" of the American Society of Naval Engineers, Vol. 23, No. 4, and Vol. 24, No. 3, we beg to say that while we agree in some respects with Lieutenant Lyon, we differ entirely from him in other particulars.

In the "Journal" of the A. S. N. E., Vol, 23, No. 4, pages 1080 and 1081, in the course of a paper on boiler compounds, Lieutenant Lyon classes graphite with hydrochloric acid under the heading "Dangerous Compounds." He does not claim, however, that graphite is an acid nor that it is a solvent for steel. He bases the analogy between graphite and hydrochloric acid on the alleged fact that both corrode the metal underneath boiler scale, and so cause its removal.

He further states that "steel boiler plate immersed in distilled water containing graphite in contact with the metal corrodes from 200 to 400 per cent. faster than specimens from the same plate immersed in the same water without the graphite, all other conditions remaining the same. The amount of corrosion varies with the purity of the graphite and with the amount of it in contact with the metal.

He also says in Vol. 24, No. 3, p. 858, "With boiler-plate steel in distilled and sea waters containing graphite, pieces covered with graphite lost from 3 to 4 times as much per square inch of area exposed as did similar pieces placed in the same water without graphite. The increased rate of corrosion depended to quite a large extent upon the percentage of area covered and also upon the purity of the graphite."

This is not a fair statement because the experiments were apparently not made under boiler conditions, but were conducted in the open air with free access of oxygen.

It is well known that under these conditions graphite and other forms of carbon do accelerate rusting of steel in water, but when no other air is admitted to a boiler except the air dissolved in the water, the conditions for corrosion by atmospheric oxygen are not favorable. The presence of graphite in a boiler would not stimulate corrosion perceptibly, because of the very limited oxygen supply and also because the steel surfaces are rarely free from a thin covering of some sort, which would insulate the graphite particles from actual contact with the steel.

It should be clearly understood that graphite is in no sense a corroding agent of the acid type, and it is only connected with corrosion of steel when it is in contact with it in the presence of water and a plentiful supply of oxygen. These conditions do not exist in boilers, and furthermore, the amount of graphite ordinarly used (3 oz. per 1000 gal.) is so small as to be insignificant, even if boiler surfaces were always clean and oxygen were freely supplied.

In order to answer by direct experiment Lieutenant Lyon's statement that graphite in water causes steel to corrode 3 to 4 times as rapidly, we made the following tests:

1. Distilled water.
2. Distilled water with graphite (30 oz. per 1000 gal.).
3. Artificial sea water.
4. Sea water with graphite (30 oz. per 1000 gal.).

350 c.c. of boiling water was used for each test, and the water which evaporated was replaced with hot distilled water. After boiling all day, the surfaces of the solutions were covered with melted paraffin. This served to only imperfectly exclude the air.

The experiments began Mar. 19. After Mar. 21, the specimens of steel stood in the beakers till Mar. 27, so that the total time in the water was 8 days, of which only 13½ hours represented actual boiling.

Rusting took place in all cases. The original weights and losses in weight are given below:

	Original weight grams	Loss in weight grams
1. Distilled water	6.5039	0.0126
2. Distilled water with graphite	6.7885	0.0179
3. Artificial sea water	6.6608	0.0193
4. Sea water with graphite	6.5515	0.0175

It will be observed from the above tests that in the presence of 10 times as much graphite as is ordinarly used for boiler-water treatment and with a somewhat limited oxygen supply, there is really no material difference in the rates of corrosion. The amount of corrosion was slightly less in sea water containing graphite and slightly more in pure water centaining graphite, but these differences are, in our opinion, not sufficiently marked to be significant. They certainly do not bear out Lieutenant Lyon's figures.

Although not representing boiler conditions, we have endeavored to repeat Lieutenant Lyon's experiments of subjecting steel in open vessels to the action of boiler water, with and without graphite.

In these experiments we used water containing 3 oz. of graphite per 1000 gal., and we found in this case also, after a number of hours boiling, that there was no material difference in the losses of weight of the steel specimens.

Yours truly,
Pittsburgh Testing Laboratory,
JAS. A. HANDY,
Research Director.

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Building Managers' Convention

The sixth annual convention of the National Association of Building Owners and Managers was held at Cincinnati on June 10 to 13, inclusive. The business sessions of the association and the exhibit of the machinery and supply houses were both held in the Music Hall.

An ample entertainment program was provided which included a long automobile ride and a dinner at the Zoological Gardens on Wednesday and an excursion on the Ohio River to Coney Island, Thursday.

At the election on Friday the following officers were chosen: President, J. E. Randell, Chicago; vice-president, C. E. Doty, Cleveland; secretary, C. A. Patterson, Chicago, re-elected; treasurer, L. L. Banks, Pittsburgh.

The next convention will be held at Duluth.

Two or three of the papers presented should be of general interest to our readers and these will be abstracted in early issues.

Influences Affecting American Engineering Practice*

By WILLIAM FREEMAN MYRICK GOSS, M. S., D. Eng.†

[The theme presented by this address was selected by the American Committee on Arrangements for the Leipzig meeting, and is in part the result of suggestions received from German sources. In its development important assistance has been rendered by a number of individuals, each of whom has generously submitted by way of suggestion a brief covering some one of the topics which the author had chosen for presentation.—Author.]

We have come to this country in response to an invitation from the largest organization of professional engineers that the world has thus far seen, and we approach your threshold thoughtfully. We remember your history and understand something of the debt of obligation which engineers everywhere owe the scientists of the German Empire. We recall the fact that foundations for the development of mathematical truth were laid by Gottfried Wilhelm Leibnitz, born more than 250 years ago in this city of Leipzig, and we know the later work of Euler, and the present-day contribution of Professor Klein. We do not forget that modern engineering has profited greatly by the discoveries of chemists, like Bunsen, Baeyer and Liebig, and of the physicists like Helmholtz, Hertz, Nernst and Roentgen. As steam engineers, we recognize our debt to Clausius, Robert Mayer and to Hirn, to Zeuner, Koerting, von Linde, and Stodola. As manufacturers, we find interest in the great accomplishments of August Borsig, of Alfred Krupp, and of Werner von Siemens. A study of the internal-combustion engine leads at once to the achievements of Otto, Langen, Daimler and Diesel; students of locomotive performance know well the work of von Borries and Wilhelm Schmidt; and the success of your great national museum has kindled our enthusiasm for its Director, your distinguished State Councilor, your energetic president, our good friend, Dr. Oskar von Miller.

In the United States as elsewhere, the percentage of the total population engaged in trade, manufacturing, mining and transportation has increased, and the percentage engaged in agriculture has diminished. These changes have attended the growth of the country's engineering activities. The transfer from agriculture to other pursuits has proceeded because people felt the need of transportation, of implements, and of conveniences in many different forms which can be supplied only by nonfarmer labor. The process of supplying these needs has constituted the engineer's opportunity. If his methods in the production of coal are wasteful, it must be remembered that in the United States coal in the ground is of little value, and that for several decades past the demand for output has doubled the annual coal production of the United States every ten years.

If some of his American railroad construction lacks qualities thought essential in European practice, it must be remembered that in the United States there is today but one family for each 100 acres of land and that the engineer's problem has been to supply transportation facilities not only between great cities, but also over vast areas of thinly populated territory. If it happens that a railroad designedly of a secondary character is made to render service which in speed and weight of trains should only be expected of a better-constructed and better-equipped road, the mistake may be serious, but the error is more likely to be one in management than in engineering.

INDUSTRIAL DEVELOPMENT

In development of manufacturing industries the American engineer has responded to similar influences. Whatever may have been the nature of the thing manufactured, if it met a real need, an extensive market was immediately at hand. The making of sewing machines and other conveniences of the home, of structural-steel shapes, railway iron, locomotives, railway cars, railway signal equipment, machinery, electrical apparatus, power-plant equipment, and more recently of automobiles and autotrucks, has pushed the ability of factories to the utmost and necessitated a constant increase in capacity. In many lines of endeavor the requirements of a new, extensive and growing country have made it possible to produce enormous quantities, and this fact has had its influence on the methods employed in manufacture.

One result of the very great demand for manufactured articles has been the exaltation of the machine. The high cost of labor also has stimulated its introduction. The general-purpose machine has steadily given way to machine designed to perform specific operations. The engine lathe, which was formerly a dominant figure in most metal-working establishments, and which is still useful in general repair work, is now regarded as an expensive tool for specific manufacturing purposes.

The extensive use of special machinery in any manufacturing industry imposes heavy responsibilities upon its engineering staff. The various steps to be taken in fabricating the article are reduced to the smallest practicable number, are made as direct as possible, and proceed in a predetermined order. Then the machines to be employed are selected, or if not available, are designed and constructed. When the establishment begins its operations, the part each operator is to perform will have been defined. The development of these matters is for the most part a task for the engineer, and one result which has attended the extensive use of special machinery in the manufacturing industries of the United States, is to be seen in the numerical growth and in the increased technical strength of their engineering staffs.

The importance attaching to the machine as a factor in industrial production has emphasized the necessity of maintaining equipment in a high state of efficiency. Machines, even when too new to be in need of repair, should sometimes be thrown out to make room for those of higher efficiency or greater capacity.

If the manufacturers of the United States have been more ready than the people of other countries to proceed with such changes, they have had a greater incentive for so doing in the higher price of their labor, for the higher the cost of labor, the greater the amount of capital which may be spent in replacing existing machines, or in installing new machines for the purpose of reducing labor costs.

TENDENCY TO COMBINATIONS

In the development of American engineering industries, there has ever been a tendency to combine undertakings. Short lines of railroads have been joined to form longer lines, and these in turn have been consolidated into greater systems. Manufacturing establishments producing similar products or similar groups of products have been united to form a great corporation under a single management, and these combinations have brought about great concentration of effort and output, the volume of which has had its effect in modifying the developing engineering practice.

Through combination, public-service companies have achieved results equal in significance to those obtained by the manufacturer. In the absence of combined effort, the business of supplying a city with electrical energy is divided among several interests. One company may maintain a power station and a distributing system for electric-lighting, another a similar station and distributing system for street railway power, another may serve interurban railways, another steam-railway terminals, and other companies may supply electrical energy to miscellaneous consumers for commercial purposes.

In contrast with this, now stands the single public-service corporation, which is equipped to supply a whole community with electricity for all purposes, rather than to supply a portion of that which is needed in competition with or duplicating the facilities of other companies. The volume of the combined business permits the elimination of many small and inefficient generating units and the substitution therefor of large units of the highest practicable efficiency. Under a single ownership duplication of feeder lines and distributing facilities may be avoided. When current can be drawn from any source of supply to any point of consumption, the reserve power to meet emergency demands may be less than when divisions of the whole system must rely upon their own sources of supply. The peak loads of different classes of service occur at different hours of the day, and at different seasons of the year. When all classes of service are combined into a single system, the load factor is improved and the amount of installed power required to supply the service is reduced by this diversity factor.

These considerations may easily allow a single public-service corporation, supplying a community with electricity for all purposes, to perform its function with a power installation, the cost of which may be from 30 to 60 per cent. less than that which would be required in an uncombined duplicative service. Obviously, a corporation rendering such a consolidated service to a single city may extend its operations to a group of cities and to the intervening country. Under favorable conditions, the greater the area of territory over which the system spreads, and the greater the number of interests served, the greater will be the load factor of the system provided the single system is permitted to fur-

*Extracts from the address prepared by the president of the American Society of Mechanical Engineers and delivered at the joint meeting with the Verein Deutscher Ingenieure at Leipzig, Germany, June 23, 1913.

†President of the American Society of Mechanical Engineers, Dean of the College of Engineering, University of Illinois.

ish the entire electric service within the areas covered. he maximum limit to which such a system may be extended as not yet been reached in American practice, though in ertain large cities of the United States a single large cor- oration is now serving electricity for all purposes, and the ame is true of groups of towns, often covering hundreds f square miles of rural territory.

The advent of the great corporation has introduced new roblems in organization. The early conception that such orporations could be directed and controlled by adminis- rative methods identical with those which had served for maller ones has not been justified. Different organizations ave worked out different solutions, but the tendency in all ases has been to subdivide the administrative function in uch a way that business may be expedited without dimin- shing the advantages of centralized control.

SCIENTIFIC MANAGEMENT

Among the significant movements which have affected ecent engineering practice in the United States is the cam- aign for higher efficiency in operation, best known as "scien- ific management." This assumes that there is one best way or doing everything; that if practice is diverse, it is because ll factors affecting it are not known; and that "the best nanagement is a true science resting upon clearly defined aws, rules and principles as a foundation." The develop- ment of scientific management involves, first, the discovery, nd, second, the application of the laws, rules and principles which control each particular problem. Applicants for posi- ions are examined that the unfit may be rejected and that he precise nature of the work to which the accepted individ- uals are best adapted, may be determined. The selected man s then trained in the performance of his task.

The effect of scientific management upon the workman himself appears to be entirely satisfactory. His wage has often increased to limits never before reached by artisan or laborer and he is a contented as well as an effective work- man. Its effect upon the industry also is favorable, since whatever increases the output of the individual workman tends to increase the earning capacity of the plant.

Again, the principle that a man to do his best at work must be in good physical condition, is receiving recognition. The man of whom such is expected must have rest and proper food. The home life of the workman, therefore, becomes an important factor in the efficiency of the industry. In many of these matters American industries have in the past been shamefully negligent, and it is interesting, though per- haps not entirely creditable, that attention should now be given them chiefly as an outgrowth for a campaign for in- creased industrial efficiency. In the development of this aspect of scientific management, America is finding much to emulate in German practice.

EDUCATION

The activities of the American engineer have been sup- plemented and greatly stimulated by the influence of vari- ous educational processes. Illiteracy in America is rare. The normal child of the most humble worker is taught something of the facts of science, history, and literature. The elemen- tary public schools commonly provide eight years of training and carry the pupil until he is 14 years of age. If he is able to delay efforts in self-support beyond this age, the public high schools afford four addition years of training for both boys and girls, in the classics, in languages, in mathematics and in science. Girls may be trained also in the various departments of domestic science, and boys in the mechanic arts. The high school prepares for the work of the university or for the technical school. Following the excel- lent models developed by your own Professor Kirchensteiner, of Munich, vocational schools paralleling the first two years of the high school are likely soon to become common.

Important also among educational influences are the daily newspapers abounding in the discussion of questions of public interest and giving not only the local news, but the world's news. In quite another class are the trade journals. These are published weekly or monthly, are attractive in form and present readable and instructive material of interest to the particular classes of men to which they make their appeal.

Important also among the influences which are effective in education, are many semiscientific and semitechnical or- ganizations which enroll large numbers of members, hold meetings, or conventions, at fixed times, and publish the pro- ceedings of these meetings for the benefit not only of mem- bers, but of any one who may be interested Whenever men's work causes them to fall into groups, they are likely to have their organization and their organization's publication. In addition to the publications of organizations, there are the high-grade technical magazines or journals, and the pub- lished proceedings of the more strictly scientific and engi- neering socities. Taken altogether, they furnish an educa- tional influence of tremendous import. The wise industrial manager encourages all who are responsible to him to read and he also reads. The result is a free and altogether help- ful interchange of experiences and opinion. Trade secrets are practically unknown. What one man gains another may have. In manual arts, in science and in engineering, the practice of the country is an open book.

Finally, standing high among the educational factors which are influential in the development of American in- dustries, must be mentioned the university and the technical school. As compared with those of Germany, the American technical school has been a plant of slow growth. The tech- nical schools in the beginning emphasized the more practical aspects of engineering, leaving the matters of mathematical theory for a later time. From such simple beginnings the schools have made steady progress. Today there is nowhere in America a keener appreciation of the service which such sciences as mathematics, physics, chemistry and biology can render engineering than in the technical school. The schools are revising courses of study and they are emphasizing the fundamental methods and facts of science rather than the more easily acquired practical aspects of engineering.

Many of them, following the example so effectively set forth by the German Hoch Schule, are making contributions to engineering research, and their outlook towards science as a basis for all technical development constitutes one of the most promising aspects of our educational work. The bond between the industries and the schools, which in earlier days was uncertain, has in recent years been tremendously strengthened. The industries are now looking to the schools for the men who are to be their leaders; for facts which will be serviceable in the promotion and development of their business; and for the stimulus which is to transform present- day practice into the more perfect procedures which our ideals demand.

Cheap Electricity for Buffalo

An important decision was handed down by the New York Public Service Commission of the Second District a few weeks ago when it declared the rate schedule of the Buffalo General Electric Co. discriminatory, and thereupon set about to prescribe a new schedule based solely upon what it con- sidered a fair return upon the investment.

This action was brought about as the result of a com- plaint by Louis P. Fuhrmann as mayor of Buffalo against the Buffalo General Electric Co. and the Cataract Power & Conduit Co. The latter purchased power from the Niagara Falls Power Co., and in turn delivered it at the city line to the Buffalo General Electric Co. for $25 per electric horse- power of maximum demand.

As was expected, the companies made every effort to boost the value of their investments and the Buffalo's General Electric Co. endeavored to include a franchise value of about $2,000,000 as well as a contract with the General Electric Co. of Schenectady in which the latter received some $700,000 in stocks and bonds, but for which the Buffalo company ap- pears to have received nothing in return except the good will of the other company. Other intangibles which the defend- ant strove to have included in its investment value were an alleged contract with the Cataract Power & Conduit Co. and a "going concern value."

The greater part of these claims were denied by the Pub- lic Service Commission, its opinion with reference to the franchise value being summed up in the following words:

"If the franchise, which was a gift from the public to the company, should be made the basis of a money return, the practical result would be that the public would have to pay money to the company because it had given the company the right to occupy the public streets."

The Public Service Commission first ordered the Cataract Power & Conduit Co. to reduce its price to the Buffalo Gen- eral Electric Co. by 28 per cent., and then prescribed the following rate schedule for the latter company which repre- sents an average reduction of 25 per cent. in its former schedule:

MAXIMUM RATES FIXED BY THE COMMISSION

Residence Lighting—Available for residence consumers only.

Connected lighting load in kilowatts to be determined by actual inspection. Maximum demand to be assumed to be one-quarter of connected load.

Net rate: 7s. per kw.-hr. for first 60 hr. use of maximum demand; 4c. per kw.-hr. for next 120 hr. use of maximum de- mand; 1½c. per kw.-hr. for remainder.

General Lighting—Available for all lighting except residences.

Connected load in kilowatts to be determined by actual inspection. Maximum demand to be assumed as one-half of connected load.

Net rate: 7c. per kw.-hr. for first 60 hr. use of maximum demand; 4c. per kw.-hr. for next 120 hr. use of maximum demand; 1½c. per kw.-hr. for remainder.

General Power—Available to all power customers.

Connected load in kilowatts to be determined by actual inspection. Maximum demand to be assumed as three-quarters of the connected load.

Net rate: 7c. per kw.-hr. for first 30 hr. use of maximum demand; 3½c. per kw.-hr. for next 40 hr. use of maximum demand; 1c. per kw.-hr. for remainder.

Large Light and Power—Available for all consumers willing to guarantee a maximum demand of 10 kw.

Maximum demand determined by maximum demand meter.

Net rate, demand charge: $2.75 per kw. for first 10-kw. demand; $1.50 per kw. for each additional kilowatt demand. Energy Charge: 1c. per kw.-hr. for all energy used.

Gross rate, demand charge: $3 per kw. for first 10 kw. demand; $1.75 per kw. for each additional kilowatt demand. Energy Charge: 1c. per kw.-hr. for all energy used.

It is interesting to compare these rates with those at present in force with the New York Edison Co., which are as follows:

General Rate—Available for all consumers. The first 250 kw.-hr. of monthly consumption at 10c. per kw.-hr. Next 250 kw.-hr. of monthly consumption at 10c. per kw.-hr.; next 250 kw.-hr. of monthly consumption at 9c. per kw.-hr.; next 250 kw.-hr. of monthly consumption at 8c. per kw.-hr.; next 250 kw.-hr. of monthly consumption at 7c. per kw.-hr.; next 500 kw.-hr. of monthly consumption at 6c. per kw.-hr. Excess over 1500 kw.-hr. of monthly consumption (for the excess) at 5c.

Power Rate—The first 200 kw.-hr. of monthly consumption at 9c. per kw.-hr.; next 200 kw.-hr. of monthly consumption at 8c. per kw.-hr.; next 2500 kw.-hr. of monthly consumption at 6c. per kw.-hr.; excess over 2900 kw.-hr. of monthly consumption (for the excess) at 5c. per kw.-hr.

Wholesale Rate—First 100,000 kw.-hr. yearly consumption at 5c. per kw.-hr.; next 100,000 kw.-hr. yearly consumption at 4c. per kw.-hr.; over 200,000 kw.-hr. excess yearly consumption at 3c. per kw.-hr.; 500,000 kw.-hr. yearly consumption not to exceed $17,500; 625,000 kw.-hr. yearly consumption not to exceed $20,000; 833,333 kw.-hr. yearly consumption not to exceed $25,000; yearly guarantee, Manhattan, 100,000 kw.-hr.; Bronx, 60,000 kw.-hr.

Assume for comparison first the case of a small consumer, whose residence contains a connected load of one kilowatt. Let his monthly consumption be 15 kw.-hr. Under the revised Buffalo rates his monthly bill would be $1.05 whereas in New York he would pay $1.50.

Next assume a customer who uses somewhat more current. Let his connected load be 1.6 kw. and assume that his monthly consumption is 60 kw.-hr. Under the present Buffalo schedule he would pay $3.12. If he lived in New York his monthly bill would be $6 or practically double. The class of consumers in which the comparison is most striking, however, is the storekeeper on one of the narrow streets, who in winter is compelled to burn his lights all day long. There are a large number of this class in New York. Assume his connected load to be 1.5 kw. and he will use on an average about 250 kw. per month for which he will pay the New York Edison Co. $25. This same customer in Buffalo would pay only $7.50.

Although the price paid by the Buffalo General Electric Co. to the Cataract Power & Conduit Co. may at first seem low, it should be remembered that it is based on the kilowatts of maximum demand; that is, if the peak load for an hour or even a few minutes of the day is 10,000 kw., but the average for the day is only 5000 kw., the company still has to pay for 10,000 kw. for the whole 24 hr. Hence the average price paid by the Buffalo company is about double that which appears in the contract.

This average price per kilowatt-hour under the revised rate is approximately the same as the production costs per kilowatt-hour at the switchboard for the New York Edison Co.—a fact which discredits any contention as to the cheapness of the water power from Niagara. It is fair to assume then that the average distribution and overhead charges per kilowatt-hour for the two companies would not differ greatly. Hence the total costs should compare favorably.

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The total area of the coal fields in Georgia is estimated at 167 sq.m., the smallest coal area in the Appalachian States.

Government's Water-Power Contract Policy

"The lower the rate charged to consumers by electric-power companies the lower will be the tax which such power companies must pay to the government." Secretary Lane of the Interior Department announced this as "the heart of the policy adopted as to the disposition of water rights of the government.

Secretary Lane says these contracts are just, alike to seller rights to use the public lands and the waters of navigable streams for the development of electrical power. He is opposed to using these waters as a source of revenue to the government, but favors the fullest use of them for the benefit of the people.

After carefully considering a power project on the Pend d'Oreille River, in northern Washington, the secretary has laid down five conditions as "an ideal standard toward which to work the making of the contract between the government and the applicants for the use of the power."

1. The greater the development of horsepower, the lower the charge per horsepower to be made on the part of the government. This is intended to secure the full use of the stream.

2. The lower rate to consumers, the lower the charge on the part of the government.

3. No charge whatever for a period of five to ten years, during which the power company is finding its market.

4. Acceptance as a public utility of the state's jurisdiction over intrastate rates and service, and of Federal jurisdiction over interstate rates and service.

5. Absolute prohibition of combination or monopoly, and the right of revocation on the part of the government in the event that it is established to the satisfaction of the Secretary of the Interior or the courts that such combination has been made or that prices have been fixed by agreement with competing plants.

Secretary Lane says these contracts are just, alike to seller and consumer of the power; they are fair to the government, and they will make for the conservation and genuine development of great natural resources which are now going to waste.

⁂

Boiler Tube Bursts in New York Hospital

At 4 a.m. Thursday, June 19, a 4-in. tube of one of the two 80-hp. water-tube boilers in the Beth Israel Hospital, Jefferson St., New York City, burst, blowing the fire from the grates, injuring the engineer and a policeman and setting fire to the building.

At the time of the accident the boiler was under 110-lb. pressure. The burst tube was the first or right-hand one in the bottom row immediately over the grate. Mr. Taylor, the chief engineer, states that the tube was a new one having been put in about Oct. 15, 1912. The tubes in both boilers were cleaned thoroughly with a turbine cleaner last October.

The rip is about 2½ ft. from the front end, and is approximately 12 in. long and 8 in. wide in the center; the side next the furnace having been blown out and flattened against the wall.

The burst was undoubtedly due to a defect in the tube, as it is thin where it ripped. It appears that the tube did not become overheated because there was plenty of water in the boiler and there is no scale in the tube, even beyond the ripped portion.

Although the engineer's office is about 35 ft. in front of the boiler (a bad location), the hot coals were blown against the woodwork, starting a fire which did damage amounting to about $25. The boiler was regularly inspected by both insurance and city inspectors.

PERSONALS

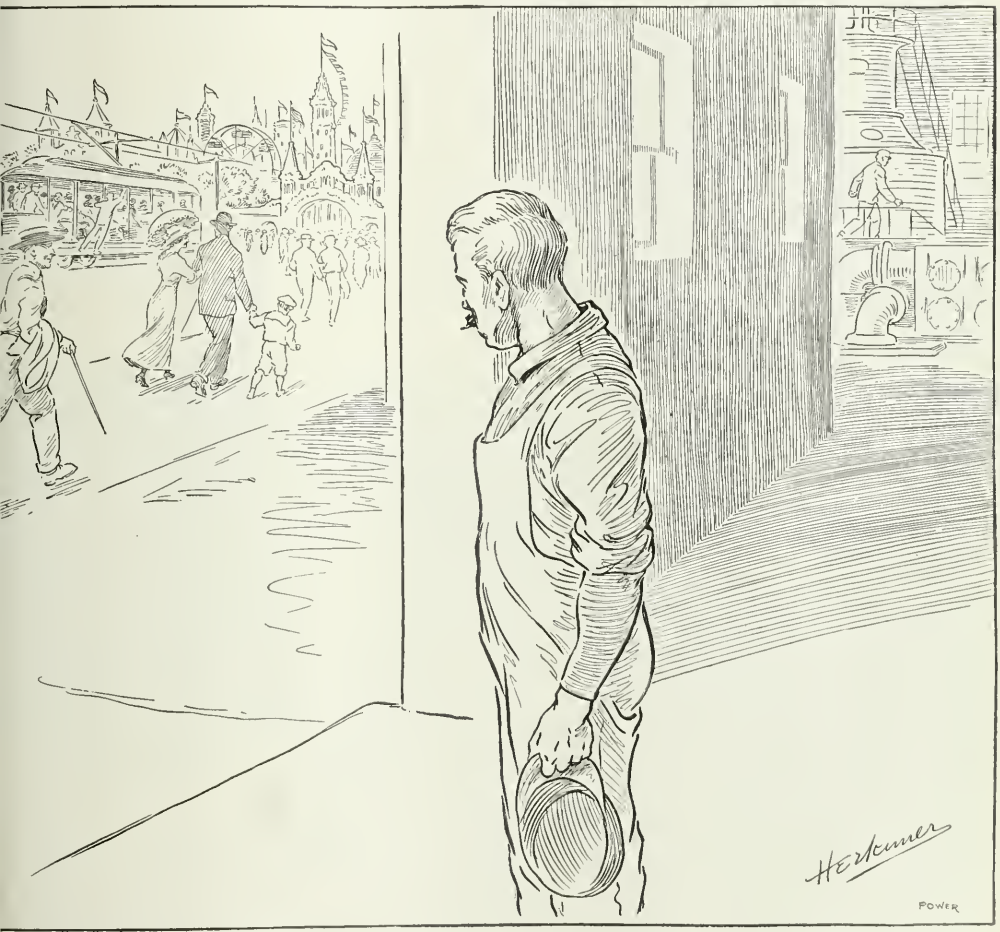
Arthur Main, formerly electrical engineer of the Hot Springs (Ark.) Water & Light Co. is now electrical engineer of the Mammoth Springs (Ark.) Power Co.

J. H. Bissell, formerly assistant treasurer of the Paducah Traction Co. and the Paducah Light & Power Co., Paducah, Ky., has been appointed assistant treasurer of the Mississippi River Power Co. at Keokuk, Ia.

POWER

Vol. 38 NEW YORK, JULY 8, 1913 No. 2

Sunday—The Day of Rest (?)



Power Plant of the Otis Building

By A. R. Mauer

SYNOPSIS—In designing this power plant, careful provision was made for accessibility, proper ventilation and recording apparatus. Air washers have been installed, and the generating machinery is of the most modern type.

The mechanical equipment of the Otis Building, La Salle and Madison Sts., Chicago, Ill., is a good illustration of modern practice with plants of its type. The building occupies a 110x190-ft. plot, it is 16 stories high with provision for five additional stories. There are some 400 suites of rooms, accommodating 1500 people, and, in addition, 15 store spaces on the street-level floor and a large space laid out for banking purposes on the second floor.

About 4000 tungsten lamps, from 40 to 250 watts in size, and some 30 motors, ranging from 1½ to 34 hp. in capacity, furnish the electrical load for the plant. The main elevators, of the Otis electric-traction type, are nine in number, eight for passenger and one for freight service.

On May 1 of last year the power plant was put into service. The generating units are four medium-speed engines, fitted with noodetaching Corliss valve-gear, and are directly connected to direct-current dynamos which generate current at 230 volts. One 12x20-in. engine has a capacity of 100 kw.; a second is 15x24 in. with a capacity of 150 kw. and the remaining two are 20x30-in. engines, each have a capacity of 300 kw. The speeds are 200, 170 and 150 r.p.m., respectively. A view of the engine room is shown in Fig. 1.

Cylinder lubrication is by force-feed pumps and the bearings by a gravity-feed central-oiling system, the pipes of which, from the overhead tank to the engines and from the engines to the return tank, are embedded in the floor. The 30x18-in. supply tank is set on brackets just outside the engine room, 8 ft. above the level of the highest bearing. The return pipes lead the oil to a settling tank and a filter in the boiler room whence it is pumped back to the supply tank by either of two 4½ and 3¾ by 4-in. horizontal duplex pumps. A 75- and a 150-amp. compensator are used to balance the three-wire distributing system. The busbars are in duplicate sets connected with a tie switch so that the power and lighting loads can be separated, thus operating one or more of the generating units on the power load and one or more on the lighting load if desired.

An objection to electric elevators is that unless a suitable preventive is employed, the sudden heavy consumption of current when starting one or more elevator motors causes a flicker of the lights, because of the momentary drop in voltage. This is prevented in this plant by using units built sufficiently heavy for the duty. Instead of being built for the more usual guarantee of 40 deg. C., maximum temperature rise under full rated load and during continuous operation the dynamos were built to satisfy a guarantee of 35 deg. C., maximum rise. They will carry a continuous overload of 25 per cent. with a temperature rise not exceeding 43 deg. and a 50 per cent. overload for two hours with a rise not exceeding 50 deg. C. The compensators are designed to carry unbalanced

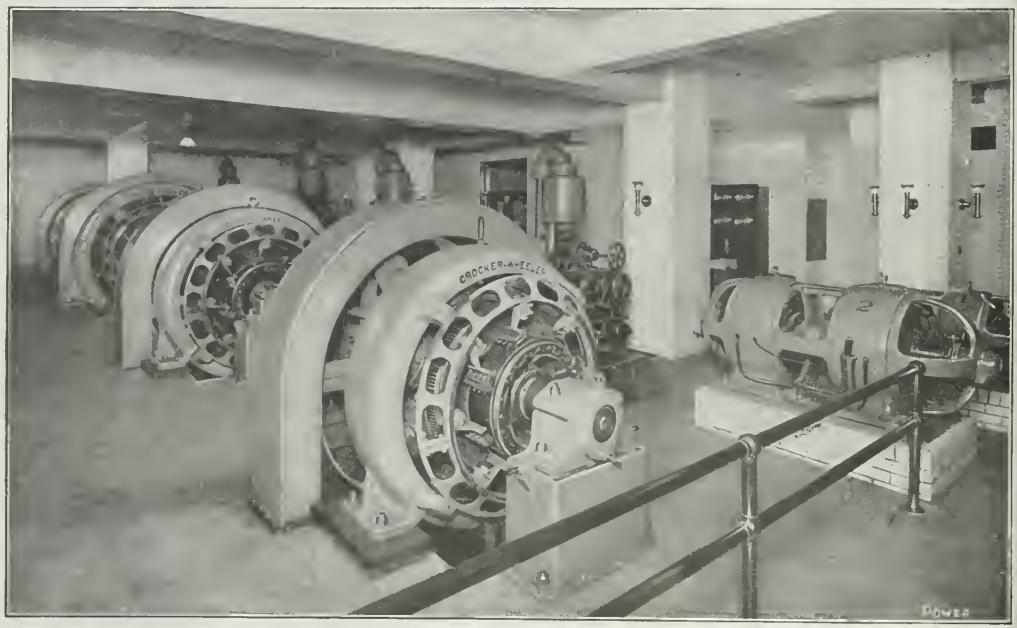


Fig. 1. Engine Room at the Otis Building

current up to their full rated capacity with a maximum variation from the average potential of not more than 1½ volts.

A 12-panel switchboard, Fig. 2, is used; the first four panels are for the generators and are equipped with the usual complement of switches and instruments. The rheostats are motor operated. The fifth and sixth panels are for the compensators and are fitted with line, rheostat and equalizer switches. The seventh panel is given over entirely to the 12 integrating wattmeters, four of which are for the main dynamos, two on the general lighting circuits; two on elevators, one on the ventilating fan-motor circuits, one on the stoker motor, one on the coal-car trolley and traveling-weight hopper feeder, and one on the coal-conveyor circuit. The next three panels carry the switches of the various main lighting circuits and the last two, the power-feeder switches.

Located on the south wall of the engine room is an automatic damper regulator which, in addition to controlling the main damper, varies the speed of the chain-grate stoker motor or engine to suit the load requirements.

A gage board, also located on the south wall, makes it possible for the engineer on watch to observe whether the various auxiliaries located in the boiler room are giving normal service. Gages also show the steam pressure in the main header, house-tank pressure, surge-tank pressure, air pressure for the thermostatic system of heating control, compressed-air receiver pressure, compressed-air pressure for the sewage ejectors, pressure in the heating-system expansion tank and the vacuum in the heating-system returns. A recording steam gage registers the main steam pressure and a differential-draft gage indicates the draft at the main damper.

A visitor entering the engine room, which is on the second basement level, 26 ft. below the sidewalk, is impressed, first, with the unusually attractive finish of the apparatus as well as of the room itself and, second, the comfortable condition of the air in the room. The walls are finished with white enamel-faced brick, the floor, with mosaic tiles, and the ceiling with a coat of light-gray paint. The machines, including the compensators, are also painted light gray.

All steam piping in the engine room is painted the same shade as the engines. The lighting fixtures are dull-brass single-light pendants from the ceiling, carrying 250-watt tungsten lamps, and single-light brackets on the building columns carrying 40-watt tungsten lamps.

The engine room is mechanically ventilated and the air is washed before it is forced into the room, purging the air of dust and dirt, cooling it in summer and humidifying it in winter. Last summer the air in the engine room was from 3 to 10 deg. cooler than on the street, even in the shade. Air is drawn in from the outside through a sheet-iron duct, the intake of which is above the roof line of the neighboring buildings, and after passing through the washer it enters the fan which forces it into the engine room. In all there are nine fresh-air supply ducts, eight located on the north wall of the engine room 8 ft. above the floor line and one in the chief engineer's office at the same height. A corresponding number of ducts located on the opposite wall at the same height conduct the foul air to the exhaust fan, which discharges it through a duct leading to the roof.

The air washer consists of a rectangular galvanized-iron compartment connected on one side with the air-intake duct and on the opposite with the ventilating fan. It contains sets of spray nozzles which form sheets of water through which the air must pass in order to reach the fan. At the inlet side of the washer is a set of tempering coils to prevent freezing in winter and for warming the air before it strikes the water and thus rendering it capable of taking up a greater amount of moisture. The nozzles are arranged in two planes so that two sheets of water are formed. The water is circulated by a 2-in. motor-driven centrifugal pump which draws its supply from the settling basin in the bottom of the washer and delivers it to the nozzles at a pressure of about 12 lb. per sq.in. After passing through the nozzles the water falls to the settling basin and is used over again. Makeup water to take the place of that which is evaporated and carried away by the air, is automatically supplied through a float valve. Once a week

FIG. 2. SWITCHBOARD AND COMPENSATORS

the washer is cleaned and flushed out and an entirely new supply of water is put in.

After passing through the two curtains of water the air goes through the "eliminators," then through another set of heating coils and finally through the fan. The "eliminators" are simply three sets of flat deflector plates extending across the path of the air and set at an angle of 45 deg. These eliminate the particles of entrained water in the same manner that a steam separator eliminates moisture from steam.

There are four other washers in the plant, employed for cleansing the air used in as many other parts of the building. The engine-room air washer has a capacity of 12,000 cu.ft. per min. and requires the circulation of 75 gal. of water per min. for this duty.

BOILER ROOM

In order to economize in width and in height, part of the boiler room extends under the engine room, as shown in Fig. 3, and numerous pieces of apparatus which do not require much head room, such as pumps, compressors,

etc., are located in this part. A plan view of the boiler and pump rooms is shown in Fig. 4.

There are three 300-hp. water-tube boilers, equipped with chain-grate stokers and baffled vertically. Under ordinary conditions the stoker shaft is belt connected to and driven by a 7½-hp. motor. In emergencies the motor belt is slipped off, the belt to a 5x5-in. vertical steam engine is slipped on, and the stokers are driven by the latter.

Flue gases are lead through a sheet-iron flue of gradually increasing sectional area to a 7-ft. steel stack, 250 ft. high, lined with vitrified asbestos. This stack rises through a square shaft in the building and extends 30 ft. above the roof. A plan view of the engine room and a partial plan view of the boiler room is shown in Fig. 5. Fig. 6 is a view in front of the boilers.

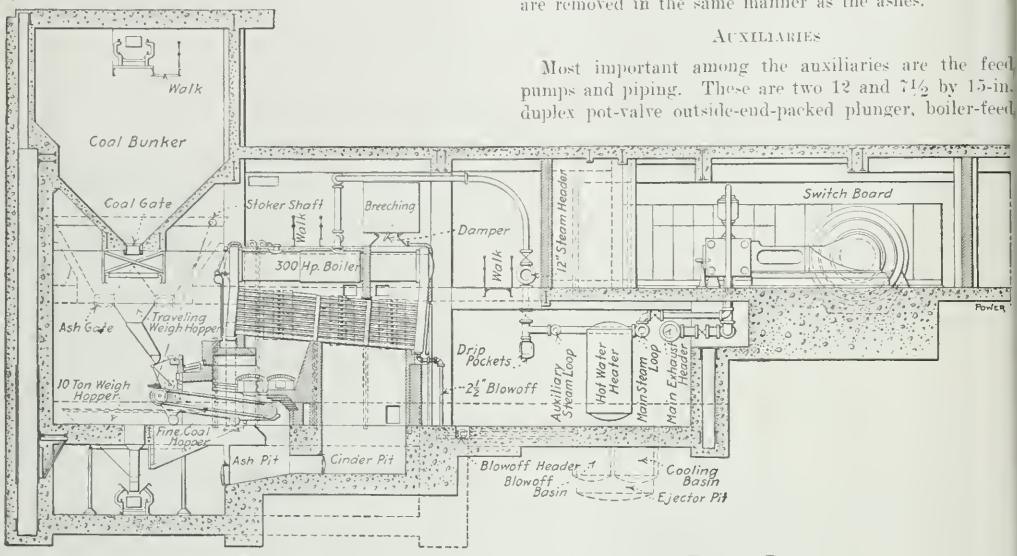


Fig. 5. Cross-Section through Pump, Boiler and Engine Rooms

Coal is delivered through the Illinois tunnel into a side tunnel connecting with the building in cars of three tons capacity, drawn by electric locomotives. The cars are unloaded into a 10-ton weighing hopper which delivers the coal to the 24x18-in. buckets of the coal and ash conveyor. The conveyor extends up the end wall of the boiler room and across over the coal bunker, which is suspended over the space in front of the boilers. It returns down the opposite wall and under the floor, Fig. 7, where it receives the ashes and delivers them to the ash bunker suspended over the end of the railroad tracks in the tunnel. The coal bunker, built of reinforced concrete, is divided into four compartments, each of which has a capacity of about 100 tons. A railroad siding is provided in the branch tunnel belonging to the building which is large enough to hold 12 coal cars. Thus, a consignment of 36 tons of coal can be switched in and unloaded when convenient.

From the bunkers the coal is fed into a traveling weigh hopper, and after being weighed is delivered through a chute to the stokers as required. This hopper runs on overhead tracks and is operated by electricity.

The space directly beneath each boiler is divided into three parts. The front part, beneath the stoker and which with ordinary hand-fired grates is the ashpit, receives the fine unburned coal which sifts through the grate. This coal is fed onto the conveyor and put back into the bunker. The middle part is the ashpit and receives the ashes as they are dropped off of the end of the grate. From this pit the ashes are fed onto the conveyor when it is not delivering coal and deposited in the ash bunker over the tracks. The rear part is beneath the last two passes of the boiler and receives any cinders which drop out of the current of gas passing through. This cinder pit connects with the ashpit and the cinders are removed in the same manner as the ashes.

Auxiliaries

Most important among the auxiliaries are the feed pumps and piping. These are two 12 and 7½ by 15-in. duplex pot-valve outside-end-packed plunger, boiler-feed pumps. The feed pipes are in duplicate, as shown in Fig. 4. A 3-in. venturi meter with the registering mechanism located in the chief engineer's office gives a daily chart of the quantity of water fed to the boilers.

Compressed air is required at different pressures for tube cleaning, the sewage ejectors and the thermostats. Either of two single-stage, steam-driven, compressors, 8 and 8 by 8 in. in size furnish air at 80 lb. pressure, which pressure is used for the first-mentioned service. The compressors deliver the air to a 36x84-in. receiving tank from which a 36x84-in. tank for the ejectors is supplied through a reducing valve with air at 40 lb. pressure; a 24x48-in. tank for the thermostats is supplied with air at 15 lb. through another reducing valve.

Water for house service is pumped to the two 2500-gal. storage tanks on the roof by either of two 12 and 7½ by 10-in., duplex, pot-valve, outside-end-packed plunger pumps, located as shown in Fig. 8. The condensate from the heating system is pumped to the receiving tank by either of two 10 and 12 by 12-in. simplex vacuum pumps. The 48x96-in. receiver tank is suspended from the boiler-room ceiling and receives the drips from the high-pressure steam piping, the water from the boiler-furnace water backs and the cooling water from the air-compressor jackets in addition to the heating returns. The com-

pressor jacket water is first employed in the house-pump control system. The feed-water heater is fed by gravity from the receiving tank through an automatic float-operated valve. Makeup water, fed direct from the city main into the receiving tank, is also regulated by a float valve.

Hot water for house service is supplied by two closed heaters, 54 in. in diameter and 8 ft. long, each capable of heating 2500 gal. of water per hour from 40 to 170 deg. F. Each heater contains 288 brass tubes, 1¼ in. in diameter and 2 ft. 6 in. long. Because of the short tubes these heaters contain large hot-water storage space and thus are capable of satisfying momentary heavy demands. The hot water circulates by gravity, a 3-in. return pipe connects with the ends of all the main feed lines throughout the building.

As part of the building is below the sewer level, three 50-gal. automatic sewage ejectors are provided, two located in a pit in the boiler room, Fig. 9, and one in the coal-conveyor tunnel. The sewage from the low parts of the building flows to these ejectors, and is automatically discharged to the sewer, 40 ft. above, when they become filled. The ejectors are operated by compressed air at 40 lb. pressure.

Boiler-feed water is heated in a twin-type open heater. Substantially, the heater consists of two 1000-hp. units combined in one shell, which is made oval. This arrangement saves considerable piping and a number of valves and fittings without dispensing with the advantage of having a duplicate heater equipment, because one-half of the heater may be shut down for cleaning or repairs while the other half is retained in service.

High-Pressure Piping

Except for a small portion of each engine lead, all piping is grouped in the boiler room. This eliminates heat radiation and improves the general appearance of the engine room. Grouping the piping is also an advantage from the standpoint of operation and maintenance, because related valves are on the same level and all the piping can be inspected and repaired from the boiler-room floor.

A 6-in. lead from each boiler rises vertically 6 ft., connects through an elbow with an automatic stop and check

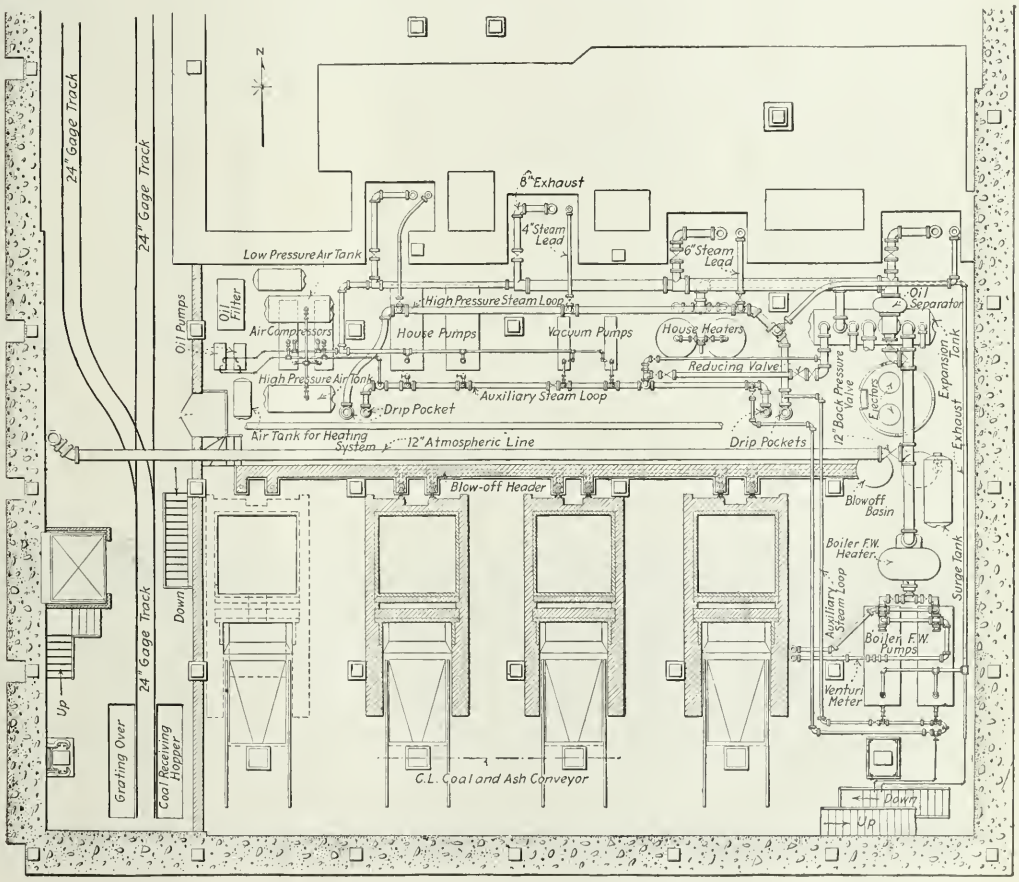


Fig. 4. Plan of Boiler and Pump Rooms

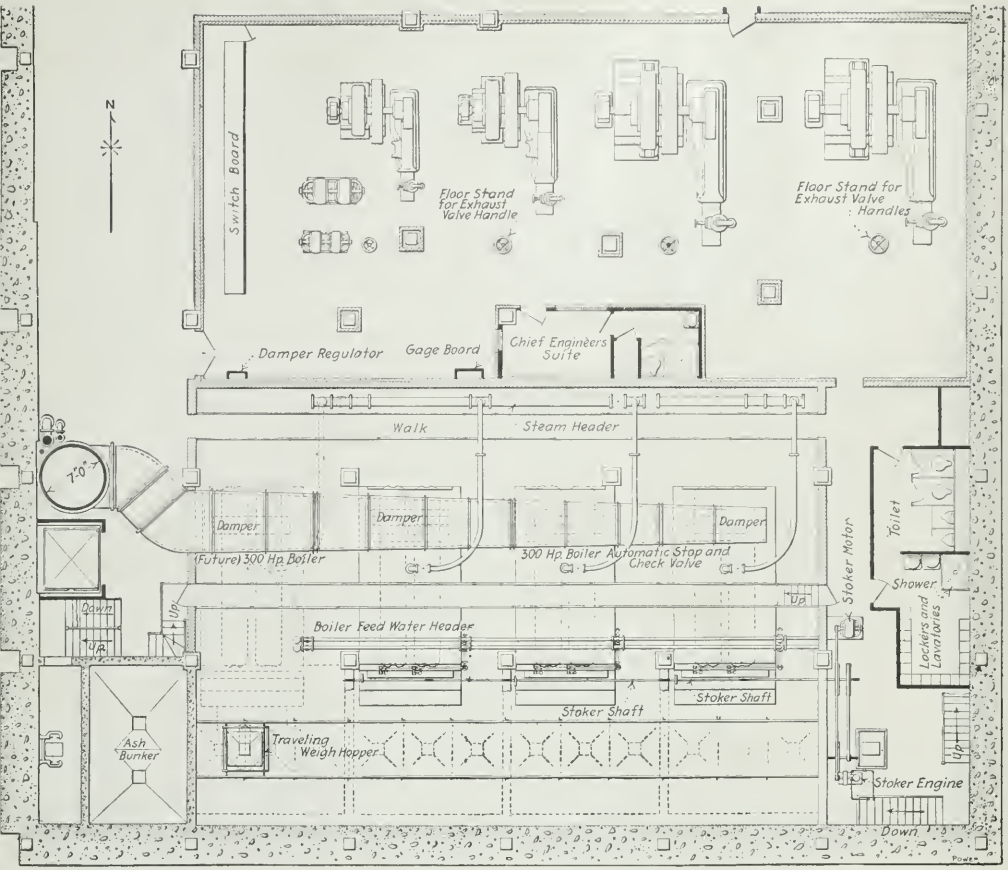


FIG. 5. PLAN OF ENGINE AND PART OF THE BOILER ROOM

valve and then through one horizontal and one vertical long-radius bend with the 12-in. main header, on the boiler-room side of the engine-room wall and slightly above the floor level of the latter room. A gate valve in each lead close to the header and one on each side of the middle boiler lead in the header itself make it possible to isolate any unit or section at will.

The principal valves are reached by iron runways, Fig. 10, which extend across the boiler room and communicate with the corridor at each side.

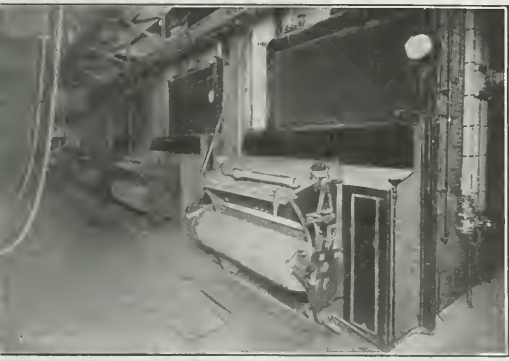


FIG. 6. THE BOILERS

FIG. 7. ASH-HOPPER OUTLETS

An 8-in. loop, to supply only the main engines, and one leg of the 3-in. loop for the boiler-feed pumps and stoker engine, connect with each end of the main header. At the east-end, connection is made between the leads of the middle and end boiler. When the fourth boiler is installed the loop connection at the west end will also come between one boiler lead and the rest.

The loop connection at each end drops 5 ft. 6 in. straight down to the level of the horizontal portion which is hung 24 in. below the boiler-room ceiling. An ample drip pocket at the bottom of each connection leg receives the condensation from the loop which is returned to the receiving tank through the medium of a trap. The horizontal section of the loop extends 11 ft. 6 in. north through a long-radius reverse bend at one end and standard 45-deg. fittings at the other, to where the straight-run portion, 40 ft. long, lies close to and parallel with the north wall of the boiler room. Each engine lead branches out of the top of the horizontal section, extends north horizontally to a point below and to one side of the center of the cylinder and then straight up through the floor to a point a little above the cylinder, where it connects through a 180-deg. fitting with a steam separator mounted on top of the throttle.

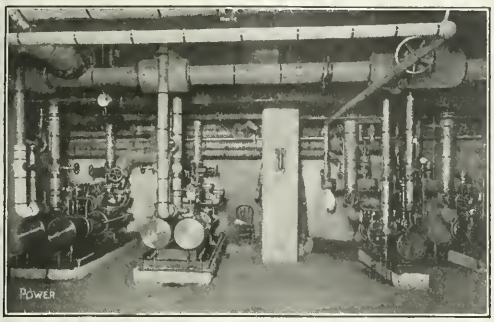


Fig. 8. House and Return Pumps

One leg of the 3-in. auxiliary loop which supplies the boiler-feed pumps and the stoker engine, branches off close to the east end of the 8-in. loop; the other leg branches off the east end of the main auxiliary loop.

This main 6-in. auxiliary loop is arranged in a manner similar to the 8-in. loop, except that the straight-run portion is but 36 ft. long and lies only 3 ft. north of the vertical legs. From this loop leads extend to the oil pumps, air compressors and the house and vacuum pumps. It is also connected with the expansion tank through a 4-in. and a 6-in. pressure-reducing valve in a line which increases successively from 4 to 6 and 10 in. in diameter. There is a 2-in. bypass around these valves for emergency use.

Exhaust Piping

Commencing at the vacuum pumps midway in the length of the boiler room an exhaust main of gradually increasing size extends west to collect the exhaust from the auxiliaries at that end and then returns along the north wall to the expansion tank in the northeast corner, collecting the exhaust from the main units on the way. At the tank the exhaust main is 18 in. in diameter. A 4-in. branch exhaust pipe extending south to the feed pumps and the stoker engine enters the main exhaust close to the tank. There is an oil separator in the exhaust main at the expansion tank.

From the expansion tank an 8-in. line supplies the house-service heaters; another 8-in. line supplies the ventilating fan-heating coils; a 14-in. line supplies the direct-radiation system throughout the building; a 12-in. line supplies the feed-water heater, and a 5-in. line supplies the first floor and first basement heating system.

A 12-in. atmospheric exhaust line connects with the line from the expansion tank to the feed-water heater through a back-pressure valve and extends to the roof through a pipe shaft at the west side of the building. The exhaust main is bypassed around the expansion tank to the 12-in. feed-water heater line so that the tank can be cut out without cutting out the heater also.

All steam and water piping is extra heavy with screwed flanges and flanged fittings and is covered with 1½-in., 85 per cent. magnesia covering.

Operating Records

C. H. Langs, chief engineer, under whose supervision the plant was designed and erected, wisely provided means for acquiring and placing on record complete operating data. The means of acquisition are coal- and ash-weighing equipment, feed-water meter, wattmeters on the vari-

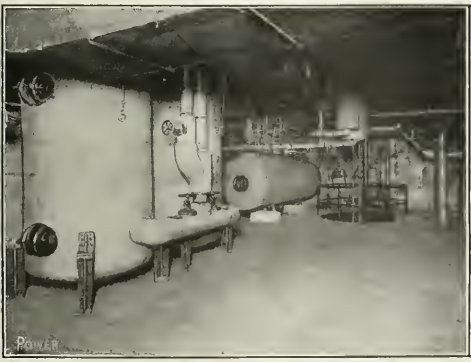


Fig. 9. Heater, Receiver and Ejector

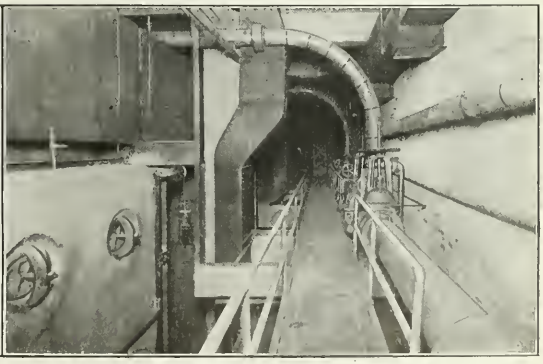


Fig. 10. Main Steam Header

PRINCIPAL EQUIPMENT OF THE OTIS BUILDING POWER PLANT

No.	Equipment	Make	Purpose	Kw.	Volts	R.p.m.	Size	Pres. lb.	Hp.	Manufacturers
1	Engine	Ball	Main units			200	12x30″			Ball Engine Co.
1	Engine					170	15x24″			
2	Engines					150	20x30″			
1	Generator	Direct current	Main units	100	230	200				Crocker-Wheeler Co.
1	Generator			150	230	170				
2	Generators			300	230	150				
1	Air washer	Kinealy	Washing air							Kauffman Heating & Engineering Co.
3	Boilers	Water tube	Steam gen.						300	Edge Moor Iron Co.
3	Stokers	Chain	Boiler furnace							Green Engineering Co.
2	Pumps	Duplex	Boiler feed				12x7½x15″			Henry R. Worthington
2	Compressors	Single stage	Air				8x8x8″	80		Laidlaw-Dunn-Gordon Co.
1	Meter	Venturi	Water				3″			Builders Iron Foundry
2	Pumps	Duplex	Tanks				12x7½x10″			Henry R. Worthington
2	Pumps	Simplex	Returns				10x12x12″			Union Steam Pump Co.
2	Heaters	Closed	House water				54″			Wm. Barawanath & Son
3	Ejectors	Automatic	Sewage				50 gal.			Merritt & Co.
1	Heater	Open	Feed water							Elliott Co.

ous circuits and mileage recorders on the elevators. The means of recording consist of a complete set of report sheets, part of which is shown herewith, arranged for filing in loose-leaf books.

To begin with, there is a "Coal Received" report. This shows the time of receipt and the weight of each shipment and the section of the bunker to which it was delivered; also, the time and weight of ash removals. Then, there is a daily "Coal Burned" report. This shows the amount of coal burned in each boiler during each watch and the section of the bunker from which the coal was derived.

Thus, with these two reports, is shown the amount of coal received, on hand and burned each day; and the latter in connection with the feed-water meter record shows in a rough way the relative amount of work done by each boiler.

A daily wattmeter report, not shown, is made, which gives the total current generated, the current distribution and consumption, and which, when used in connection with the elevator-service report and other records, is important in estimating operating costs and similar data.

It is also useful in estimating repair and operating costs for the elevator equipment.

Finally, there is the daily engine-room report, Fig. 11, which gives the ammeter readings on the generators and the operating records of all the important apparatus in the plant as well as a summary of the coal consumed, ashes handled and evaporation obtained.

Otis Building

Engine Room Daily Report

Date_____ 191__

AMPERE READINGS							HOURS OF SERVICE					REPAIRS ETC
Time	1	2	3	4	Volts	Amperes	MACHINE	Started	Stopped	Started	Stopped	Hours on
7.00 a.m.							Generator No. 1					
8.00 "							" No. 2					
9.00 "							" No. 3					
10.00 "							" No. 4					
11.00 "							Compensator No. 1					
12.00 m.							" No. 2					
1.00 p.m.							Oil pump No. 1					
2.00 "							" " No. 2					
3.00 "							House pump No. 1					
4.00 "							" " No. 2					
5.00 "							Air compressor No. 1					
6.00 "							" " No. 2					
7.00 "							Vacuum pump No. 1					
8.00 "							" " No. 2					
9.00 "							Live steam on bldg					
10.00 "							" " " "					
11.00 "							Hot water heater No. 1					
12.00 "							" " " No. 2					
1.00 a.m.							Ejectors					
2.00 "							Boiler No. 1					
3.00 "							" No. 2					
4.00 "							" No. 3					
5.00 "							" No. 4					
6.00 "							Boiler feed pump No. 1					
Total Amperes Hours							" " " No. 2					
" K. W. "							Stoker No. 1					
COAL AND ASHES							" No. 2					
Coal—1st shift							" No. 3					
" 2nd "							" No. 4					
" 3rd "							Coal conveyor					
Ashes—1st shift												
" 2nd "												
" 3rd "												
Coal received												
Venturi meter												
Evaporation per lb coal			lbs									

FIG. 11. DAILY REPORT SHEET

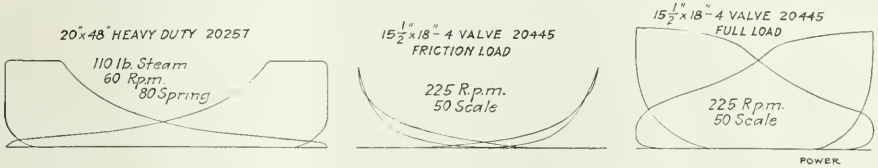
Corliss versus Four-Valve Engine

By C. R. McGahey

In the present discussion we are considering only those engines having four round valves of the Corliss type. There is merit in a properly built four-valve engine, but many of them are not equal to the Corliss engine in economy. The builders of four-valve engines admit the advantage gained by the quick movement of the Corliss valve over the manner of obtaining quick movement of a valve operated by a nonreleasing gear, as with the four-valve engine.

Superheating the steam by wire drawing, would certainly be very limited in the four-valve engine, and I attach no importance to statements pretending to make this a good feature of such engines.

The diagrams shown are from a four-valve engine having the valves in the cylinder body and using Corliss double-ported valves, with the steam ports on the lower part of the circle. This engine, 15½x18 in., showed a steam consumption of 24 lb. per i.hp., with an initial pressure of 100 lb., 225 r.p.m., and exhausting directly to the atmosphere. I have run tests on this four-valve engine in connection with a surface condenser, and it showed equal results, as compared with Corliss condensing or noncondensing. With this gear the valves on this four-valve engine have a large throw, much more than the ordinary four-valve engine, and double-ported instead of triple-ported valves. Consequently there is less port clearance space through the valve.



Diagrams from Corliss and Four-Valve Engines

Many of the four-valve engines that port above a center of a circle will leak, as the valve will wear away from its seat and the clearance will be considerably increased. At 220 r.p.m. this 15½x18-in. engine gives a piston speed of 665 ft. per min. To compare this with an 18x36-in. Corliss engine running at 90 r.p.m., we would have practically the same horsepower and a piston speed of 540 ft. per min., and this speed may be increased up to 665 ft. per min. There is but little question as to this latter engine showing a better economy than the four-valve engine. The steam or waste clearance is greater on the four-valve than that on the Corliss, being about 8 per cent. while that on the Corliss is about 4 per cent. The thermal loss is greater in the four-valve engine, as the temperature of the cylinder is changed about twice as often as with the Corliss engine.

The angularity of the connecting-rod will considerably affect the steam distribution of the four-valve engine, and the load will determine the time element in the working of the valve-gear. It will be noticed from the set of cards presented that the steam distribution of the four-valve is quite good, considering the angularity of the connecting-rod, as compared with the angularity which obtains in the Corliss engine, but the Corliss engine has no short toggles in its valve motion. The movements of the valve-gear of the Corliss are of a high velocity.

Most of the four-valve engines have so many joints in their valve-gear, and these joints are of such short radius that it is almost impossible to keep them in a good running condition. Many four-valve engines when first installed will produce an indicated horsepower-hour on 25 lb. of steam, but after a comparatively short service they take 29 lb. and more.

There is but little need for running a Corliss engine above 125 r.p.m., as it is then hard to keep the dashpots so that they will close with a velocity much above the speed of the piston. Therefore, nothing is gained by using the releasing gear. When the four-valve engine is built with proportions of about 12x24 in., good economy will be shown when running at about 165 r.p.m., as this speed will not cause wire drawing, nor require excessive port clearance to permit of the required steam velocity.

Some of the best economies that have been attained by the four-valve engine have been obtained by having a comparatively long stroke and with the cylinder completely jacketed and the valves so located as to reduce clearance to a minimum. Then, again, many four-valve engines cannot be long-range engines on account of having a shifting eccentric that will not give a constant lead.

Power from Waste Heat

West Hartlepool, England, says a consular report, which claims to be the first municipal authority to produce electricity by means of waste heat, will open its new generating station shortly. The two turbo-generators, each of 1500 kw., will be driven by exhaust steam from the furnace-blowing engines of the Seaton Carew Iron Co., adjacent to whose works the station is built. In return for their exhaust steam, which has hitherto been blowing to waste in the air, the Seaton Carew Iron Co. will receive current free from the corporation.

Expenditure on coal will practically be eliminated. The coal bill for the present electricity station is about $20,000 a year, and, as it is anticipated that the consumption of current will largely increase under the cheaper rate now possible, the ultimate saving by the use of waste heat will be very considerable. Should the supply of exhaust steam not be available, either through a breakdown of the blowing engines or through the iron works being idle, a supply of high-pressure steam will be obtainable from the Seaton Carew Iron Co.

The total expenditure involved in connection with the new scheme is $188,500, the plant alone having cost $150,000. The old generating station will be maintained as a stand-by and as a town substation. There the current from the new station will be transformed to the voltage required for distribution to the town.

Power Aboard the "Imperator"

SYNOPSIS—Like all up-to-the-minute liners, the "Imperator" is turbine driven, working on the triple-compound system under an initial pressure of 235 lb. per sq.in. The total horsepower of the propelling units is 62,000. The boiler-heating surface is 203,000 sq.ft., grate surface 3760 sq.ft. This is 64,000 sq.ft. more heating surface than the Cunarder "Aquitania" and 43,650 sq.ft. more than the "Lusitania," although her rated horsepower is only 2000 greater than the "Aquitania" and 6000 less than the "Lusitania." The normal speed is 22.5 knots per hour.

The quadruple-screw, turbine-driven, Hamburg-American liner "Imperator," which had its keel laid June 18, 1910, was launched May 23, 1912, and docked at Hoboken, N. J., June 19, 1913, has a wonderfully complete power plant. This is to be expected in a ship 919 ft. long, 98 ft. beam, whose height from keel to top-mast is 246 ft., and whose weight is 50,000 tons.

Boilers and Draft System

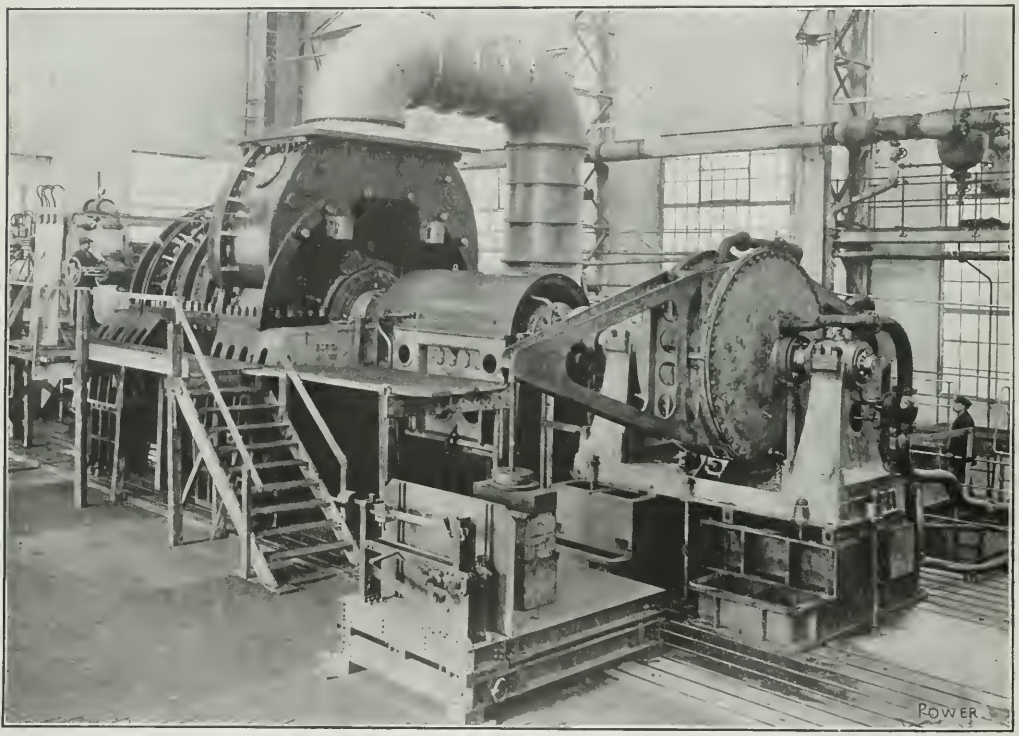
Commencing with the boiler room there are 46 single water-tube boilers in four rooms, each 75 ft. long and separated from each other by water-tight bulkheads. The boiler rooms and coal bunker alongside take up the entire width of the vessel. The steam pressure carried is 235 lb. per sq.in. The draft is furnished by four fan blowers (Howden system), each of which is 13 ft. 9½ in. in diameter. The ducts conveying air from the fans to the grates are each of 15 sq.ft. cross-section. The three smoke-stacks or funnels tower 69 ft. above the upper deck. A section of one of the funnels is shown in Fig. 5. They are elliptical and measure 32 ft., on the major axis and 18 ft. on the minor axis.

Ash-Handling Equipment

Here one finds the ash-handling equipment, consisting of a cooling apparatus, four ash ejector pumps, capable of handling 6356 cu.ft. per hr. in connection with 16 ash ejectors and six ash hoists. An idea of the amount of ash to be handled is gained from the following: Assume a coal consumption of 2 lb. per hp.-hr. and that the vessel is developing its rated horsepower of 62,000; the coal containing 10 per cent. ash. Then in 10 hr. the weight of the ashes will be

$$[(62{,}000 \times 2) \times 0.10] \times 10 = 124{,}000\ lb. = 62\ tons$$

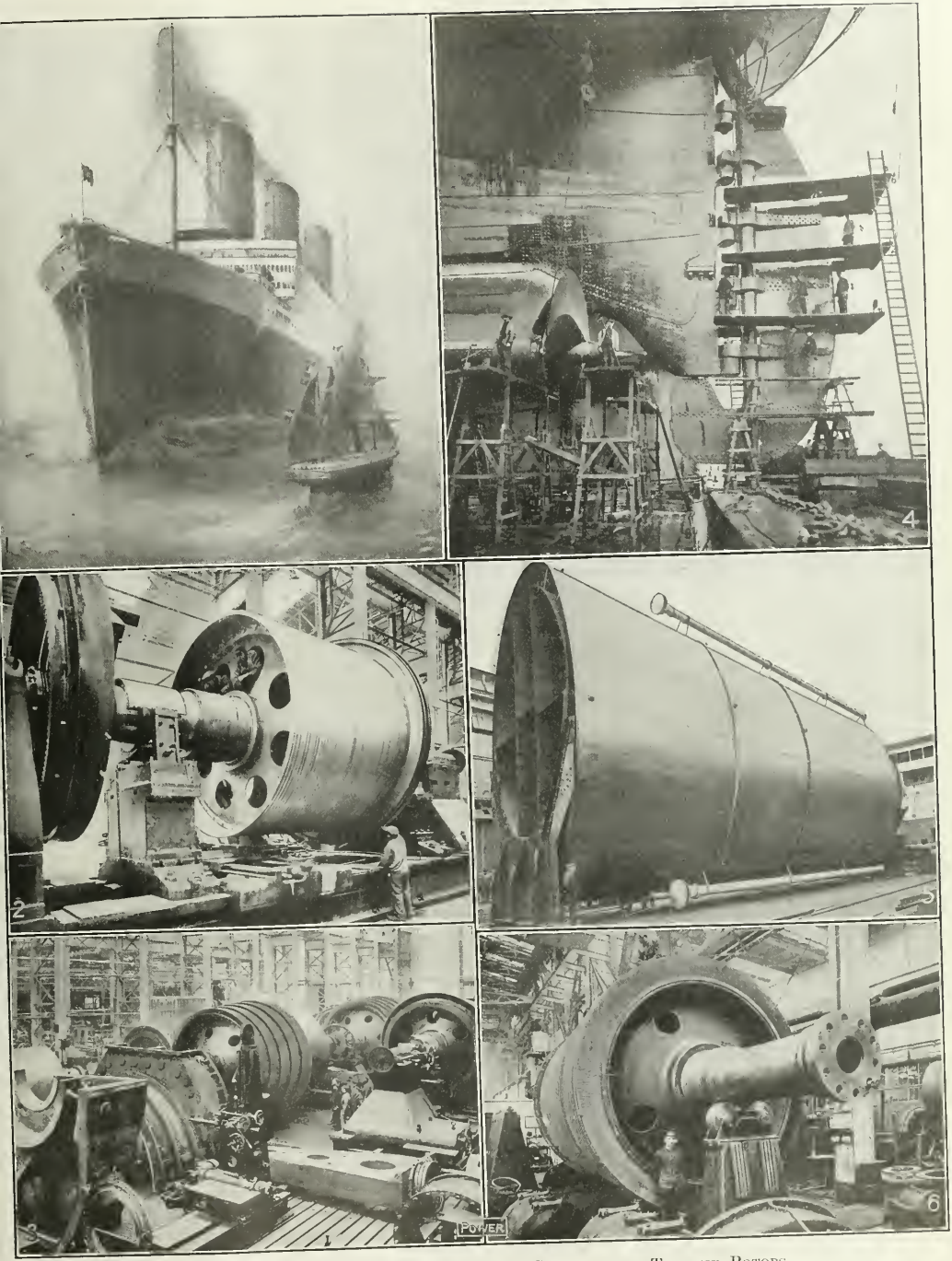
The weight of water in the ashes due to wetting has not been considered.



Brake Test of One of the "Imperator's" Turbines

Heaters and Evaporators

Besides the four feed-water purifiers, two oil separators, two mixing feed-water heaters and two economizers, there



The "Imperator," Her Rudder, Funnel Section and Turbine Rotors

are three 2-step evaporators capable of furnishing 100 tons of feed water every 24 hours.

Turbines

The total forward driving effort of the turbines is 62,000 hp., at 185 r.p.m., through four 4-winged screws of turbadium bronze, each about 16 ft. 5 in. in diameter. The backward driving effort is approximately 35,000 hp. Ordinarily, or when going ahead, the steam passes to a high-pressure turbine on an inner shaft, then to an intermediate-pressure one, also on an inner shaft, and then on to two low-pressure turbines of equal power on the outer shafts; each turbine having its own shafts, which may be run independently for maneuvering. The reverse turbines are four in number, two high- and two low-pressure turbines with the two low-pressure machines on the outer shafts.

The total number of bronze blades in all turbines is 760,000, which, if laid end to end, would have a length of 125 miles. Each one of the low-pressure turbines, complete, weighs 380 tons and develops 16,000 hp. Each of these turbines has 50,000 blades on the rotor. Views of the rotors during construction are shown on the preceding page. One of the high-pressure turbines being tested with a huge water brake is shown on page 50.

Condenser Equipment

Four Weir dual air pumps take the condensate from the condensers and discharge it to two great tanks in the double bottom. Four duplex feed pumps take this water and, working in conjunction with the four main feed pumps, deliver it to the boilers. For port service there are two auxiliary condensers having their own two circulating and two air pumps. Two "drainage" pumps are connected with the turbine casings to draw out condensate that accumulates there.

Oil under pressure is forced to the bearings of all turbines by six pumps, while the shaft bearings are lubricated by oil supplied under pressure by two additional pumps. Four bilge pumps of approximately 37,000 gal. hourly capacity continuously pump water from the bilges of the engine and boiler rooms.

Electric Generators

Five turbo-generators, situated aft; each have a capacity of 2000 amp. at 110 volts. These generators furnish light and power, the power consumption of the various motors being about 850 hp. An emergency oil-engine-driven electric-generating set, of 100 amp. capacity, at 110 volts, is located on the boat deck and is connected so as to furnish current for the 1500-mile-range wireless apparatus as well as for lighting important parts of the ship in case of breakdown of the main electrical units. A battery furnishes current for the elaborate intercommunicating telephone system which connects every stateroom with various parts of the ship.

One gets an idea of the plumbing (under the care of the chief engineer) when it is said that in the first cabin alone there are 229 regular baths and showers, including 146 private bath rooms.

One of the screws and the steel rudder, which weighs 90 tons and is 57 ft. 6 in. high, is shown on page 51.

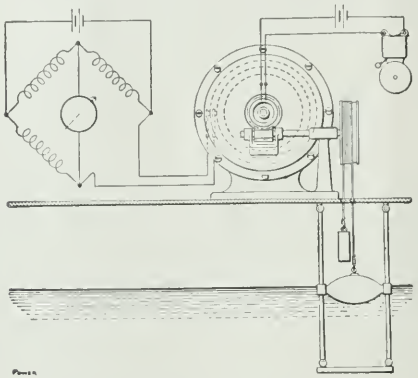
The ship carries two motor life boats equipped with wireless apparatus of 200 miles range.

Continuous Recording Remote Water Gage

The continuous indicating water gage, designed by Dr. A. Koepsel, Charlottenburg, Germany, shows on an index whether the water level is rising, falling or constant.

A mechanically variable electrical resistance is employed, so connected to a float that when the latter rises the resistance will increase and when it falls it will decrease. These variations in resistance are transmitted to a galvanometer by means of a Wheatstone bridge.

In the illustration a rope is shown wound several times around a pulley with a weight attached to one end. The other end is attached to a float which runs on guides. The vertical reciprocating motion of the float is converted into a rotary motion which is transmitted by a worm or toothed wheel to a slate disk on the periphery of which is a resistance wire, connected with electric current by two sliding contacts. By the rotation of the disk, the length of wire between the contacts, and accordingly its resistance, is altered. As the resistance forms the fourth



Continuous Recording Water Gage

branch of a Wheatstone bridge, the galvanometer in the diagonal branch of the bridge continually indicates its variations.

The apparatus is rendered independent of the distance of transmission by adding to the variable resistance a constant resistance, the amount corresponding to the resistance cut out at the leads. Any variations in the temperature of the leads can be compensated by a resistance in the adjoining branch of the bridge.

At the points of the slate disk, corresponding to the highest and the lowest positions of the float, contacts can be arranged, the closing of which sounds an alarm bell calling the attention of the staff to these two limits.

The apparatus comprises two leads and is operated either by connection to the mains or to a 2-4-volt storage battery. It has been successfully used in several installations.

The number of hydro-electric power plants is increasing steadily and rapidly throughout Japan. There are 383 companies now engaged in furnishing power and they operate 620 waterpower batteries. The total horsepower developed at the present time is over 2,000,000.

Luitwieler Double-Acting Triplex Pump

In the construction of the Luitwieler triplex pump, shown in Fig. 1, cams take the place of cranks to produce the reciprocating motion. These cams are placed 120 deg. apart on a shaft and the shape of the cams is such as to

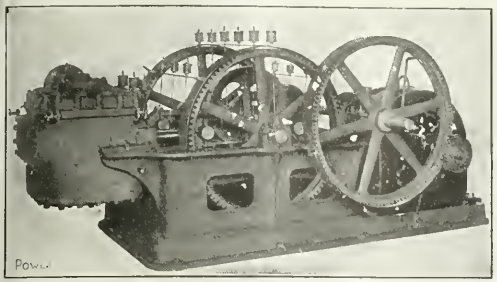


Fig. 1. Luitwieler Double-Acting Triplex Pump

cause the plunger to produce an even flow of water throughout the complete cycle. Fig. 2 is a plan view of the pump.

The 3¼-in. shaft and cams are in balance, which, with the even flow of the water, allows maintaining a high speed. In operation, the cams work against rollers, Fig. 3, at either end of the crossheads which give a reciprocating motion to the crossheads and the pistons, which are connected by rods working through packing glands. The three cams work in slots in the frame on either end of the cam shaft and the driving gears. The cam shaft rests in six bearings, each gear and cam having a bearing on either side.

As the pump is double acting, the labor performed by the cams is uniform throughout the cycle; the pressure on opposite sides of the bearings is equal and for this reason a small diameter shaft is used.

The crossheads are of bronze; the slippers move in a straight line through planed guideways. Gibs hold the slippers in place; fiber shims allow adjustment for wear. The pump is bored to receive brass linings 6 in. in diameter by 12 in. stroke. The pistons are of bronze with turned water grooves, and on each end is a leather cup which expands by the water pressure and prevents slip. The bonnets are arranged with a screw plug over each valve so that a defective valve can be immediately located, and taken out through the handhole in the center by the removal of six bolts.

Fig. 3. Cams and Rollers

An air check and cock locates any defective valve or spring which is indicated by the action of the pressure gage. Without the use of an air chamber the gage variation is less than 5 lb., due to the closing of the valves, which indicates a small slip.

Efficiency tests made by electrical engineers report as high as 87½ per cent. efficiency in the motor-driven pump.

This pump is manufactured by the Luitwieler Pumping Co., 123 Ames St., Rochester, N. Y.

[This is a remarkable efficiency even for high-pressure delivery, and must be understood to be for the pump alone and not to include the motor.—Editor.]

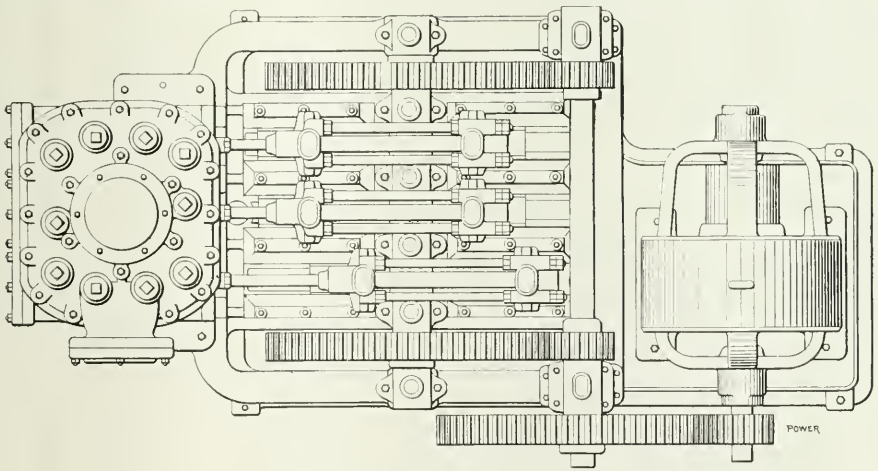


Fig. 2. Plan View of the Pump

ELECTRICAL DEPARTMENT

Constant-Voltage Transmission*

By H. B. Dwight

In deciding upon the method of operation of a transmission system, two distinct alternatives are presented, one of which has been brought forward but recently. In the older method, which is the one in common use, the voltage of the system is controlled entirely from the generators. The chief disadvantage is the large variation in voltage, which is the factor limiting the carrying capacity of the system. In the newer method there is no voltage variation at all, this result being obtained by controlling the voltage from both the generating and the receiving ends. The newer method also greatly increases the carrying capacity of a transmission line, and has been used successfully in commercial operation, though as yet only on small systems.

The method in common use with transmission lines needs no description as it consists merely of controlling the voltage on the line by adjusting the voltage of the generators. At no load the two ends of the line are at approximately the same voltage, while under load there is considerable drop at the receiving end and a variation in voltage is unavoidable as the load increases or decreases.

When a load on a transmission system becomes so large as to produce too great a variation in voltage for good service, it has been customary to construct additional transmission lines, or to adopt a higher line voltage. It is at this stage that constant-voltage transmission appears most attractive, as it provides greatly increased carrying capacity without any alterations in the transmission line itself.

In the constant-voltage method, instead of controlling the voltage from one end only, synchronous motors are installed at the receiving end, and the voltage is controlled at that end by adjusting the power factor. The way in which the synchronous motors operate to hold the voltage constant is very similar to the way in which they are used to improve the power factor. A large part of the voltage drop in a transmission line is due to the line reactance, which is greatest at a low power factor, and it is, in fact, directly proportional to the lagging reactive component of the load. The drop is, therefore, changed into a rise in voltage if the reactive component is leading instead of lagging, and this may be sufficient to overcome the drop due to resistance.

When it is stated that the synchronous motors must be equal to one-half or two-thirds of the generator capacity the cost will at first sight seem prohibitive. In consideration of this, however, the additional fact must be considered that the newer method not only improves the service, but greatly increases the carrying capacity of the line. Since with a line of about 100 miles in length the cost of the generators is comparatively small compared with the cost of the line, the installation of synchronous motors will actually save money in large systems, by saving extra line construction.

The limit of carrying capacity is ordinarily set by the maximum variation in voltage allowed for good service; but if there is no voltage variation at all another limit must be looked for, and this will be found in the greatest energy loss which can be allowed for the transmission. Power for supplying line losses costs very little in most systems, so that an efficiency of 85 per cent. is generally consistent with good economy.

The carrying capacity of a 25-cycle line can be doubled by adopting the constant-voltage method, and that of a 60-cycle line can be multiplied by two or three. For 60 cycles, the cost of a constant-voltage line with the necessary synchronous motors represents a saving when the length is over 70 miles. For 25 cycles the saving over the varying-voltage method is not obtained until the length is 120 miles or more.

High reactance is a detriment to a line operating with varying voltage but is not a great disadvantage when the constant-voltage method is used. The reactance of the entire circuit includes that of the generators, step-up transformers, protective reactance coils, and step-down transformers, as well as the line reactance. It has been customary in large systems to make all these reactances as large as possible for protective reasons, in spite of the fact that they tend to make the regulation poor, and so limit the power which can be transmitted. High reactances give protection by reducing short-circuit currents, and when placed between the line and the station apparatus give very effective protection against abnormal voltages, due to lightning and to surges caused by switching. It is evident that with constant-voltage transmission it will be economical to increase all these reactances much beyond the values in use at present and better protection will thus be obtained.

It may safely be stated that the reason why the frequency of 25 cycles was adopted to any extent in this country was because its low reactance made it more economical for transmission. With constant voltage, however, 60 cycles becomes as economical as 25 cycles, and except for railway work, 60 cycles is preferable in most cases. The cost of generators, transformers, and motors is generally less at 60 cycles, and the operation of most lighting devices, especially tungsten lamps and arcs, is much more satisfactory at the higher frequency.

The most advantageous application of constant-voltage transmission is probably not in transmission lines with a single generating station, but rather in large transmission networks connecting hydro-electric plants and the cities within a radius of several hundred miles. The generators placed at various points of the network themselves partly take the place of the synchronous motors for maintaining constant voltage, and thus the total capacity of synchronous motors required is somewhat less. Duplicate lines

*From a paper presented at the annual convention of the American Institute of Electrical Engineers, Cooperstown, N. Y., June 25, 1913.

for use as reserves in case of breakdown are not required as much in networks as in straight transmission projects, since power can generally be supplied to any point from more than one direction. Thus a small number of heavy lines can be used in networks, and the constant-voltage operation is especially applicable to these.

When larger transmission networks are advocated it might be objected that the limit has been already reached as to the number of generating stations which can be connected to one network, owing to the danger from such large amounts of generator capacity when a short-circuit occurs. But a network which is operated at constant voltage contains an unusually large proportion of reactance, both in the line and in the station apparatus. Thus when a short-circuit occurs the voltage drop toward the short-circuit is very rapid and the power is delivered to it practically only from the near-by generating stations.

The two systems, varying-voltage control and constant-voltage control, have been described as being quite distinct. There is, however, a middle ground between them. For instance, consider a line operated with 20 per cent. voltage variation at the generators between no load and full load, and with a steady voltage at the receiving end. Now by installing a small number of synchronous motors at the receiving end, the generators may be operated with only 10 per cent. variation, the synchronous motors being used to hold the receiving voltage constant. Twice the number of synchronous motors would allow constant-voltage operation at both ends. It is possible, therefore, to install a small amount of machinery and obtain a proportionate improvement in closer regulation or through an increased carrying capacity of the transmission line.

Many power companies offer special terms to induce their customers to install synchronous motors and thus raise the power factor of the load. This can scarcely be called a step in the direction of using the principles of constant-voltage transmission, since the field current of the synchronous motors is not adjusted with a view toward regulating the line voltage. The advantages of a high power factor of load are very small indeed compared with the large advantages to be obtained from adjustable power factor.

It must not be supposed that the voltage at all points of a constant-voltage transmission line or network has exactly the same value. At all points where there are generators or synchronous motors whose field currents can be adjusted, the voltage will be held steady. For the best economy, however, the generator voltage should be held at a higher value than the receiving voltage. Thus the voltage at the generating stations may be held constant at 110,000 volts, while the voltage at the receiving stations may be held steady at 90,000 volts. This involves running the synchronous motors with a weak field and a lagging power factor at no load; and there is a limit in doing this when the motors are carrying a mechanical load, due to the danger of their dropping out of step. However, the capacity of synchronous motors required is so large that most of them would have to run unloaded as synchronous condensers, since mechanical loads could be found for only a few of them. The advantages and disadvantages of the constant-voltage system may be summarized as follows:

Advantages

1. Better service—no variation in voltage.
2. Better protection, due to high reactances.
3. Tendency to use the frequency of 60 cycles.
4. Increased carrying capacity of line. The limit is changed from maximum voltage variation to maximum energy loss. This allows more power to be transmitted or the distance to be increased, without the voltage being raised.
5. Lower total cost for long lines. The saving in cost is greatest for long lines or large networks, large quantities of power, large conductors, and for the frequency of 60 cycles.
6. The method is easy to apply to existing lines. The change can be gradual, and no change is necessary in line construction.

Disadvantages

1. Cost and attendance of additional machinery.
2. Higher total cost for short lines.
3. In order to obtain the greatest economy from constant-voltage operation, the losses must be increased, and the number of separate lines, which are useful as reserves, must be reduced.
4. Tendency of synchronous machinery to drop out of step, and delay in putting load on the line again after shutdown.

Heating of Brush-Holder Studs

A new 300-kw., 250-volt motor-generator set was installed and from the start developed excessive heating of the brush-holder studs where contact was made with the leads.

The brush-holder studs are of standard design. Referring to Fig. 1, *AA* are heavy fiber washers; *BB* are nickle-plated iron washers, and *C* is a flat copper lead to the collecting rings to which, in turn, the switchboard cables are connected. The heating became so bad that the fiber washer *A* next to the brush-holders would burn, frequent

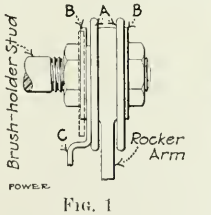


Fig. 1

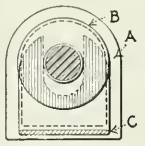


Fig. 2

Fig. 3

tightening of the nuts on the studs did not prevent the heating except for a very short time.

Upon close examination it was found that the contact of washer *B* with part *C* was not sufficient to carry the current without undue heating. The piece *C* being so far away from the brush-holder stud gave a contact similar to that shown by the shaded part of Fig. 2.

Therefore, heavy copper washers were made, shaped as shown in Fig. 3. These were substituted for washer *B* (see dotted lines, Figs. 1 and 2). Since these washers have been in use there has been no more trouble with nuts working loose, owing to the heat drying and burning out the fiber washers, and parts that were previously hot are now cooler than the studs themselves.

Michigan City, Ind. R. E. Crockett.

GAS POWER DEPARTMENT

Pressures in Gasoline Engines

By G. A. Field

The following curves, showing variations in per cent. of clearance, compression pressures and temperatures, normal explosion pressures, etc., in internal-combustion engines, have been grouped by the writer and found very convenient for rough calculations.

Curve I gives the variation of atmospheric pressure in pounds per square inch with the elevation above sea level in feet. The elevation above sea level is given from zero to 6000 ft., reading from the top of the scale downward.

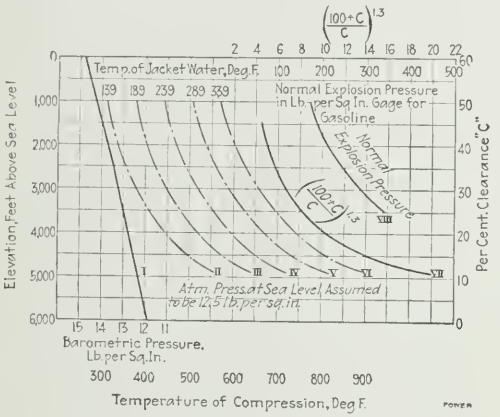

Temp. of Jacket Water, Deg. F.
139 189 239 289 339
Normal Explosion Pressure in Lb. per Sq. In. Gage for Gasoline
Normal Explosion Pressure
Atm. Press. at Sea Level, Assumed to be 12.5 lb. per sq. in.
Elevation, Feet Above Sea Level
Per Cent. Clearance "C"
Barometric Pressure, Lb. per Sq. In.
Temperature of Compression, Deg. F.
POWER

Chart for Finding Temperatures and Pressures

The barometric pressure is given from 11 to 15 lb. per sq.in., reading from right to left.

Curves II to VI, inclusive, give the variations in temperature of compression in degrees Fahrenheit with per cent. clearance C for various temperatures of jacket water from 139 deg. F. to 339 deg. F. inclusive. The per cents. of clearance are found at the right, reading from the bottom upward, and the temperatures of compression are found at the bottom, reading from left to right. Curve VII gives the variation of the quantity $\left[\frac{100 + C}{C}\right]^{1.3}$ with the per cent. clearance C and is to be used in the formula given below for determining the compression pressure for various per cents. of clearance and elevations above sea level.

Atmospheric pressure at sea level corrected for volumetric efficiency is assumed to be 12.5 lb. per sq.in. gage. Compression formula

$$P = P_a\left(\frac{100 + C}{C}\right)^{1.3} - P_a$$

The fundamental formula for the variations of pressure and volume is

$$\frac{P_b}{P_a} = \left(\frac{V_a}{V_b}\right)^n$$

where

V_a = Volume at beginning of compression;
V_b = Volume at end of compression;
P_a = Pressure at beginning of compression—usually 0.8 or 0.9 atmospheres, depending on the volumetric efficiency;
P_b = Pressure at the end of compression;
C = Clearance (per cent. of piston displacement).

The ratio $\frac{V_a}{V_b}$ = the ratio $\frac{100 + C}{C}$.

Therefore,

$$P_b = P_a\left(\frac{V_a}{V_b}\right)^n = P_a\left(\frac{100 + C}{C}\right)^n$$

Reducing to pressure above atmosphere; i.e., subtracting P_a from both sides of the equation

$$P_b - P_a = P_a\left(\frac{100 + C}{C}\right)^n - P_a$$

Let P = Pounds per square inch gage = $P_b - P_a$, substituting,

$$P = P_a\left(\frac{100 + C}{C}\right)^n - P_a$$

In which the exponent n is usually assumed to be 1.3. Having determined the atmospheric pressure P_a for the particular elevation and corrected for volumetric efficiency, find the value of the quantity $\left(\frac{100 + C}{C}\right)^{1.3}$ for the given per cent. clearance C and solve the equation for P.

Curve VIII gives the normal explosion pressures in pounds per square inch gage for gasoline corresponding to the various values of C.

Hints on Gas-Producer Operation*

By C. H. Bromley

Conceive of an air-tight steel-plate cylinder lined with firebrick, and provided with poke openings and having a grate at the bottom, a fuel hopper and inlet at the top with an outlet for the gas, and you have the essential parts of the usual gas producer or generator. Some producers, however, do not have a grate. Consider the operation of the ordinary parlor coal stove with a "feeder" containing fresh fuel; below it the decomposed coal and then the incandescent coal above a bed of ashes and you have a good idea of the operation of the usual gas producer and of the so called "zones" of fuel. The essential difference between a stove or furnace and a gas producer is in the amount of air admitted. In the case of the former sufficient air should be admitted for complete

*Excerpts from lecture before Newark, N. J., No. 3 N. A. S. E. Association.

combustion, while in the producer only a limited amount of air is admitted under the fire.

Near the producer grate, where the air enters, a small quantity of CO_2 gas is formed. On being drawn up through the deep bed of incandescent fuel, the CO_2 absorbs considerable carbon and CO, the chief constituent of producer gas, is formed. Notice that a high CO is needed in producer operation while a high CO_2 is desired in boiler-furnace operation. As the CO increases the CO_2 decreases and *vice versa.*

Steam is admitted under the grates of a producer for two principal reasons: To lower the temperature of the fuel bed and thereby prevent fusing of the ash and the formation of clinker, and to enrich the gas with its hydrogen. Too much steam in the blast increases the CO_2 and impairs the quality of the gas. Too little greatly increases the upkeep cost of the generator by permitting the formation of clinker and destruction of the firebrick walls by fusion with the ash. Experience and the kind of fuel used will alone determine how much steam to use. Should too much moisture or water vapor get into the producer with the air, the gas will be so rich in hydrogen as to probably cause premature ignition in the engine cylinder when compression occurs. Usually the amount of water vapor entering with the air regulates itself automatically. This will be readily understood when it is remembered that the hotter the producer—when more vapor is needed—the more water will be vaporized; when the producer cools less water is vaporized.

The air entering the producer furnishes oxygen to gasify the carbon, but it also contains nitrogen, an inert gas which dilutes the producer gas. For each pound of oxygen brought in by the air, 3.33 lb. of nitrogen will have entered the producer. The gas will contain by volume about 55 per cent. nitrogen.

Incident to the function of a gas producer is the distillation of fuel within it. With bituminous and semibituminous coals and lignites the distillation process results in the formation of ammonia gas, tar and other hydrocarbons. These impurities are cared for by scrubbers, purifiers, tar extractors, etc., or they may be drawn through the bed of incandescent fuel in the producer and broken up into fixed gases.

The chief troubles of producer operation are caused by the fuel used. Bituminous and semibituminous coals frequently cake and, combined with the effect of coking, in which process the coal loses about one-tenth its weight but increases about one-third in volume, the fuel forms an arch in the producer. This arch holds the fuel above, and the fuel below does not feed down evenly. The position of the zones becomes altered and cracks are formed through which weak gas rushes to the outlet, slowing down the engine. If the steam blast is not distributed uniformly over the area of the bed, cracks and channels are likely to form, producing varying temperatures in the incandescent zone and retarding the production of rich gas. These arches must be broken by poking, but if they are poked at through doors, care must be taken to not keep the doors open too long, for sufficient air may enter as to dilute the gas and cause irregular running of the engine.

It is sometimes desirable to have connections for furnishing the engine with street gas when cleaning the generator. This is especially true for places where the labor is unskilled and where the fuel contains ash that clinkers and slags. Should the gas become weak while the producer is being cleaned the engine may be supplied with street gas.

Irregular poking and removal of the ash, varying moisture content of the coal and load fluctuations tend to alter the position of the zones.

One should be careful not to strike hard blows on the firebrick lining, as producers have been made to leak in that way. Poke from the top of the generator if possible for then the bar will move parallel with the firebrick walls and there is then less chance of breaking them.

The ignition temperature of carbon is 1240 deg. F., but a temperature of 2000 deg. F. is needed for good work in producers. At this temperature the ash often fuses, forming clinker which in turn fuses with the firebrick lining. When the clinker is removed pieces of the lining chip off with the clinker. Red coal, a semibituminous grade, fuses its ash at about 1850 to 2200 deg. F., and as the coal contains much iron the slag gives great trouble.

Coal highest in sulphur does not always have the lowest fusing point of its ash as is commonly supposed. In fact, the sulphur content of a coal is not a true indication of its clinkering properties. Organic sulphur of itself has no tendency to form clinker. When sulphur as pyrites occurs in coal and if the ash is high in silica, clinker will usually result when the temperature is as high as needed in gas-producer and boiler-furnace work.

The design of most charging boxes on gas producers is such that with reasonable care air cannot be admitted to the generator at this point to create an explosion.

Always keep in mind when running suction producers that the entire system is operating at a pressure lower than atmospheric and that leaks in the generator, scrubber, piping, etc., admit air which dilutes the gas and lowers the power of the engine. Remember, too, that cleanliness is most essential to good operation. See that all elbows in the gas lines are provided with covers held in place by yokes or that tees with plugs are used instead of elbows, so that the pipe may be easily cleaned of dust and tar. Slime and dust should be removed from the gas holder at frequent intervals. If the gas is drawn through a spiral wire brush or through screens take out the brush or screens once a week and wash them in kerosene.

When starting the plant, work the fan until plenty of gas is formed before attempting to start the engine. This will be shown by a straw-colored flame which will burn when the gas escaping at the test cock is ignited; a blue flame indicates the presence of air. When the engine has started, close the test cock and the outlet flue of the generator and work the fan until the engine is pulling hard enough to generate its own gas.

Care of Magnetos

By A. L. Brennan, Jr.

Magnetos can be divided into two classes—low-tension and high-tension, but there are certain rules that apply equally to both types. These have to do with keeping the machine free from water, oil and other foreign matter.

Magnetos invariably revolve at high speeds and consequently if the bearings are not supplied with a suitable lubricant, wear will result. This wear takes place where there is the most lateral pressure which results in the bearings being worn slightly out of line and thus the armature will not revolve upon a true center. On the other hand, overlubrication is also detrimental, inasmuch as the oil has a tendency to creep. About the best way is to resort to frequent oiling, using small amounts, say, two drops each time.

Nearly all magnetos now have permanent magnets and, therefore, an operator is seldom confronted with an inoperative magneto, due to loss of magnetism, as was quite frequently the case a few years ago. Present-day troubles are invariably attributed to faulty connections or contacts, poor adjustments, or to accumulations of oil or dirt. Troubles with low-tension magnetos are in most cases due to the frictional surfaces of the armature becoming gummed or to faulty carbon brushes.

When a magneto gives trouble it is advisable to wash the parts affected in a tin of gasoline and then polish the surfaces with fine sandpaper. Emery cloth should never be used for this purpose, as small particles of carbon are likely to cause short-circuits or partial short-circuits, which are even more difficult to locate. Carbon brushes sometimes wear unevenly but this is easily remedied by rubbing the brush upon a piece of flat sandpaper, care being taken to hold the carbon at right angles to its contact surface; this treatment will insure a positive contact.

With high-tension magnetos the most troublesome parts are the points in the breaker box, these having a tendency to become pitted and cause the motor to misfire. Ordinarily, the points need only to be cleaned with emery cloth, but if badly pitted they will probably need filing and this will necessitate their removal. It is important that they be filed at such an angle that when they are in contact they will bear over their entire surface. If the points only touch on one side, for instance, the spark efficiency will be greatly reduced.

In regard to the correct gap that should exist between these points, much depends upon the magneto. However, the majority of manufacturers supply suitable open-end wrenches and gages for all necessary adjustments and an operator cannot go wrong if he will but follow these scales.

The distributor carbons are apt to cause slight trouble by not making positive contacts, but they can be trued up easily as already mentioned. Sometimes when carbons wear considerably they do not bear with sufficient pressure to insure a positive contact, which is due to the decreased tension of the spring. This trouble is easily remedied by removing the carbon and bending out the spring.

The component parts of a spark plug should be kept tightly assembled, the points clean and about the thickness of a dime apart. Inspection of the breaker points is had by removing the cover. Some operators make a practice of cleaning out this box with gasoline, but if this is done care must be taken not to slop gasoline around, for if the motor suddenly starts the gasoline in the breaker box is likely to be set on fire.

Before removing a "set" magneto, suitable timing marks should be made, for, otherwise, trouble will be experienced when putting it back.

A Successful Marine Producer Plant

About two years ago the barkentine "Archer," a boat of 900 gross tons, operated by the Tacoma & Roche Harbor Lime Co., between Roche Harbor and San Francisco, was equipped with a suction-gas power plant. This plant has proved a decided success. Although troubles have come up now and then, they could almost always be traced to improper handling of the plant.

The producer was built in Olympia, Wash., and is of 300-hp. capacity. It is, strictly speaking, a combination up-draft and down-draft type. The gas outlet is a large tube passing down the center of the producer to within a few feet of the grate, and all the gas above the lower end is drawn down through the fuel bed, then up the tube.

The washing apparatus consists of several centrifugal washers only; no tower scrubbers nor dry scrubbers being employed. These washers have given perfect satisfaction when furnished with plenty of water. As no other washing apparatus is used, the water supply requires special attention, since the lignite produces large quantities of tar.

The engine is a 300-hp., four-cylinder Nash, running at 235 r.p.m., the exhaust line being supplied with a heater, which furnishes steam for keeping the clinkers soft in the producer. A 20-hp. gasoline-electric generating set furnishes power for the air compressors and lights when the large engine is not in operation. A generator is also belted to the larger engine, so that when the boat is under way the smaller engine is shut down.

The fuel is cheap lignite, which is so plentiful in the state of Washington. This is very high in moisture, often reaching 25 per cent. It is also high in ash, averaging about 15 per cent., and, of course, is high in volatile matter with low fixed carbon.

On the "Archer" little trouble is had with clinker when the firemen work the producer properly, but when neglected, clinkers are bound to cause more or less trouble. Some time ago the firemen decided to quit, and during the last few days they were on shift neglected the producer; the result was the formation of bad clinkers.

This lignite costs from $1.75 to $2.75 per ton in the bin, depending upon the size; the pea size giving as good satisfaction as the nut. The hoppers of the producer will not readily feed coal which is larger than nut size. A supply of coal is taken on only once for the round trip from Roche Harbor to San Francisco and back.

Only two men are on shift at a time; one fireman and one engineer. The fireman handles the producer only, and, therefore, has no reason for not keeping it in good condition. Everything is arranged very conveniently for the engineer. When starting the engine he does not have to run from one place to another to close purge valves, air valves, etc., as everything is located so that all valves can be operated right at the engine.

This plant is of special interest because it has now been in operation just about long enough to give a good idea of what can be done with marine lignite gas-producer plants. The successful performance of this installation means much to the Pacific Northwest where there are enormous fields of lignite unfit for almost any purpose except gas producers. The "Archer" was the first boat of any consequence on the Pacific coast to install gas power and it has been watched with interest.

Seattle, Wash. GEORGE W. MUENCH.

REFRIGERATION DEPARTMENT

The Properties of Saturated Ammonia Vapor

Experimental data on ammonia has been meager and the tables on the properties of ammonia which have been used are known to be inaccurate in many particulars. Realizing this fact, the University of Illinois Engineering Experiment Station has carefully analyzed the available data on the subject and worked out tables of the properties of both saturated and superheated ammonia and besides a convenient chart for solving graphically the usual practical problems met in refrigerating practice. These data appear in Bulletin No. 66, just issued.

The authors, G. A. Goodenough and W. E. Mosher, were exceptionally thorough in their investigations and are to be congratulated on producing a work which is the latest and best on the subject and should be generally adopted for standard reference. Due to lack of space only the tables on saturated ammonia vapor and liquid ammonia will be presented in this issue and for the same reason some of the intermediate values were omitted toward the end of Table 2. Following is a review of what the authors have to say concerning the tables:

As in the case of steam and many other technically important vapors, the first reliable experimental knowledge of the properties of ammonia was derived from the work of Regnault. He determined experimentally the relation between the pressure and the temperature of the saturated vapor and expressed it by means of empirical formulas. He also determined the relative volumes of the superheated vapor at different pressures along an isotherm for the temperature 8.1 deg. C., the specific heat, the theoretical density and the experimental density of the gas. The determinations made by Regnault of the specific heat of the liquid and the latent heat of vaporization were lost in the reign of the Commune in 1870; twelve of the determinations of the latter magnitude, however, have been found.

The first attempt to establish the fundamental equations for the vapor of ammonia and to compute tables of its properties was made by Ledoux. These equations and resulting tables, resting as they do upon unsound hypotheses and meager experimental data, are, in the light of later investigations, quite inaccurate. The next theoretical investigation of the subject was undertaken by Zeuner, who computed new constants for ammonia, in the equation of state of the form already applied by him to steam, and used by Ledoux for ammonia. He also constructed empirical formulas for the inner and outer latent heat, and the specific heat of the liquid, and by use of these formulas computed tables which appeared in the earlier editions of his thermodynamics. In the later editions the values thus calculated have still been used for temperatures below 32 deg. F., but results of later experimental determinations have been used above that temperature. These tables for ammonia vapor are given in both English and French units.

The tables now used most extensively in refrigeration work and included in most handbooks on refrigeration are those of Wood. These tables are computed from formulas derived by the author and based upon Regnault's experiments. About the same date (1889) that Wood's tables appeared, another set of tables was published by Peabody. These tables were based upon the work of Ledoux and upon the same form of equation of state, namely, that derived by Zeuner and applied to ammonia by Ledoux, but with the constants recomputed.

Since the above mentioned tables were published the properties of ammonia have been made the subject of considerable experimental work, although comparatively little is known even now when its importance in technical work is considered. Beside the experimental work enumerated above we have the following determinations: Pressure-temperature relation by Blümcke, Pictet, Faraday, Davies and Brill; critical temperature and pressure by Dewar, Vincent and Chappuis, Jaquerod and Schaffer; latent heat of vaporization by von Strombeck, Franklin and Kraus, Estreicher and Schnerr, and Denton and Jacobus; specific heat of the liquid by von Strombeck, Ludeking and Starr, Elleau and Ennis, and Dieterici; volume (or density) of the liquid by D'Andreeff, Lange and Dieterici; volume of saturated vapor by Dieterici; volume of superheated vapor by Leduc, Guye and Ferman and Davies; specific heat of the superheated vapor by Kentel, Voller, Wiedemann and Nernst, the existing data on the latter property being summed up by Nernst. In addition to the above direct experimental determinations of the various properties of ammonia there is available a set of throttling experiments performed by Wobsa.

A great deal of the recent experimental work has been done by Dieterici. He has computed a table of the properties of ammonia, but this table is available in metric units only, and may be improved upon. In 1907, Wobsa published tables of ammonia vapor based upon his own experimental work and that of Dieterici. These tables appear in the 1908 edition of Hütte and have been converted into English units and extended for every degree Fahrenheit by Macintire. In 1908, Wobsa published a revised table based upon a new form of equation of state. Among other tables of the properties of ammonia which have appeared in metric units are those of Mollier and of Hybl.

The present investigation has been undertaken with the object of collecting and correlating the various scattered experimental data on the subject of the properties of ammonia. An attempt has been made to reconcile these data by means of well known thermodynamic laws and principles so that the results may be consistent with each other; and to express the various properties by means of formulas from which tables and charts in English units may be prepared for use in solving the many problems connected with refrigeration work.

It is fully realized that the experimental evidence is not as complete as could be desired and that more ac-

TABLE 1 SATURATED AMMONIA VAPOR: TEMPERATURE TABLE

Temp. deg. F.	Pressure, lb. per sq.in.	Sp. vol. sat. vap. per lb.	Density vapor, lb. per cu.ft.	Heat content of liquid	Latent heat of evap.	Heat content of vapor	Internal Energy B.t.u. Evap.	Entropy Liquid	Entropy Evap.	Entropy Vapor	Temp. deg. F.	Pressure, lb. per sq.in.	Sp. vol. sat. vap. per lb.	Density vapor, lb. per cu.ft.	Heat content of liquid	Latent heat of evap.	Heat content of vapor	Internal Energy B.t.u. Evap.	Entropy Liquid	Entropy Evap.	Entropy Vapor
−110	0.758	291.	0.00344		648.5		607.7		1.8548		57	101.8	2.885	0.3467	27.5	524.7	552.3	470.8	497.9	0.0537	1.0157	1.0694
−105	0.947	236.	0.00424		645.4		604.0		1.8398		58	103.7	2.833	0.3530	28.5	523.9	552.5	469.9	498.0	0.0550	1.0139	1.0678
−100	1.176	192.	0.00520		642.2		600.3		1.8251		59	105.7	2.783	0.3594	29.5	522.9	552.4	469.0	498.2	0.0563	1.0083	1.0646
−95	1.450	158.	0.00633		639.0		596.6		1.8106		60	107.7	2.734	0.3658	30.9	522.0	552.9	468.0	498.4	0.0601	1.0046	1.0647
−90	1.778	130.	0.00767		635.8		592.9		1.7960		61	109.7	2.686	0.3723	32.0	521.1	553.1	467.1	498.5	0.0623	1.0009	1.0632
−85	2.167	108.	0.00924		632.5		589.1		1.6884		62	111.7	2.639	0.3790	33.1	520.2	553.3	466.1	498.7	0.0644	0.9972	1.0617
−80	2.626	90.3	0.01107		629.3		585.3		1.6575		63	113.7	2.592	0.3858	34.2	519.3	553.5	465.2	498.9	0.0665	0.9937	1.0602
−75	3.164	75.8	0.01320		626.2		581.6		1.6271		64	115.9	2.547	0.3927	35.3	518.4	553.7	464.2	499.0	0.0687	0.9900	1.0587
−70	3.791	64.0	0.01564		622.6		577.7		1.5970		65	118.1	2.503	0.3996	36.5	517.5	554.0	463.3	499.2	0.0708	0.9863	1.0571
−65	4.518	54.2	0.01845		619.2		573.9		1.5691		66	120.3	2.460	0.4066	37.6	516.6	554.2	462.3	499.4	0.0729	0.9827	1.0556
−60	5.358	46.2	0.02165		615.8		570.0		1.5410		67	122.5	2.418	0.4136	38.7	515.6	554.4	461.4	499.5	0.0750	0.9791	1.0541
−55	6.324	39.6	0.02530		612.5		566.1		1.5134		68	124.7	2.377	0.4207	39.9	514.7	554.6	460.4	499.7	0.0771	0.9755	1.0526
−50	7.43	34.01	0.02940	−85	7.608	9.523	3.502	2.476	5.—0.1901	1.4865	1.2964	69	126.9	2.336	0.4280	41.0	513.7	554.8	459.5	499.9	0.0792	0.9719	1.0511
−49	7.67	32.98	0.03032	−84	7.608	2.523	6.561	4.476	7.—0.1875	1.4811	1.2936	70	129.2	2.296	0.4354	42.1	512.8	555.0	458.5	500.0	0.0813	0.9683	1.0496
−48	7.92	32.00	0.03125	−83	6.607	2.523	9.560	6.476	9.—0.1850	1.4758	1.2908	71	131.5	2.257	0.4430	43.3	511.8	555.2	457.5	500.2	0.0834	0.9647	1.0481
−47	8.17	31.07	0.03219	−82	6.607	2.524	3.559	4.475	2.—0.1824	1.4705	1.2880	72	133.9	2.219	0.4506	44.4	511.0	555.4	456.6	500.4	0.0855	0.9612	1.0467
−46	8.43	30.19	0.03312	−81	5.606	1.524	6.559	0.477	4.—0.1801	1.4653	1.2853	73	136.3	2.182	0.4583	45.5	510.0	555.6	455.7	500.5	0.0876	0.9576	1.0452
−45	8.69	29.34	0.03408	−80	5.605	4.524	9.558	2.477	6.—0.1776	1.4601	1.2825	74	138.7	2.145	0.4662	46.7	509.1	555.8	454.7	500.7	0.0898	0.9540	1.0438
−44	8.96	28.52	0.03506	−79	5.604	7.523	3.557	4.477	9.—0.1751	1.4549	1.2797	75	141.1	2.109	0.4742	47.8	508.1	556.0	453.7	500.9	0.0919	0.9504	1.0423
−43	9.24	27.72	0.03607	−78	4.604	0.523	6.556	6.478	2.—0.1727	1.4497	1.2770	76	143.5	2.073	0.4823	48.9	507.2	556.2	452.7	501.0	0.0940	0.9469	1.0409
−42	9.53	26.94	0.03712	−77	4.603	3.525	9.555	8.478	4.—0.1702	1.4445	1.2743	77	146.1	2.039	0.4905	50.1	506.2	556.4	451.7	501.2	0.0961	0.9434	1.0395
−41	9.82	26.18	0.03820	−76	4.602	6.526	2.555	0.478	6.—0.1678	1.4394	1.2716	78	148.7	2.005	0.4988	51.3	505.3	556.6	450.8	501.3	0.0983	0.9398	1.0381
−40	10.12	25.45	0.03930	−75	3.601	9.526	6.554	2.478	9.—0.1653	1.4343	1.2690	79	151.3	1.972	0.5071	52.4	504.3	556.7	449.7	501.5	0.1004	0.9363	1.0367
−39	10.43	24.74	0.04042	−74	3.601	2.526	9.553	4.479	1.—0.1628	1.4292	1.2663	80	153.9	1.940	0.5155	53.6	503.4	557.0	448.8	501.7	0.1025	0.9328	1.0353
−38	10.73	24.06	0.04156	−73	3.600	5.527	2.552	6.479	3.—0.1604	1.4241	1.2637	81	156.5	1.908	0.5241	54.8	502.4	557.1	447.8	501.9	0.1047	0.9293	1.0339
−37	11.07	23.40	0.04273	−72	2.599	7.527	5.551	8.479	6.—0.1580	1.4190	1.2611	82	159.2	1.877	0.5328	55.9	501.4	557.3	446.9	502.0	0.1068	0.9258	1.0326
−36	11.40	22.76	0.04393	−71	2.599	0.527	9.551	0.479	8.—0.1555	1.4140	1.2585	83	161.9	1.847	0.5416	57.1	500.5	557.5	445.9	502.2	0.1090	0.9223	1.0312
−35	11.74	22.14	0.04516	−70	2.598	3.528	2.550	2.480	0.—0.1531	1.4090	1.2559	84	164.7	1.817	0.5505	58.2	499.5	557.7	444.9	502.3	0.1112	0.9187	1.0298
−34	12.09	21.55	0.04640	−68	1.596	9.528	5.548	6.480	5.—0.1483	1.3990	1.2507	86	167.4	1.788	0.5594	59.4	498.5	557.9	443.9	502.5	0.1132	0.9153	1.0285
−33	12.45	20.97	0.04769	−68	1.596	9.528	5.548	6.480	5.—0.1483	1.3990	1.2507	86	170.2	1.759	0.5685	60.6	497.5	558.1	442.9	502.7	0.1153	0.9118	1.0271
−32	12.81	20.41	0.04900	−67	1.596	1.529	1.547	8.480	7.—0.1458	1.3940	1.2482	87	173.0	1.731	0.5777	61.8	496.5	558.3	441.9	502.8	0.1175	0.9083	1.0258
−31	13.18	19.87	0.05033	−66	0.595	4.529	4.547	0.481	0.—0.1434	1.3891	1.2456	88	175.9	1.703	0.5871	63.0	495.5	558.5	440.9	503.0	0.1197	0.9048	1.0245
−30	13.56	19.35	0.05168	−65	0.594	7.529	1.546	4.481	2.—0.1410	1.3842	1.2432	89	178.8	1.677	0.5964	64.2	494.5	558.7	439.9	503.1	0.1217	0.9014	1.0231
−29	13.95	18.85	0.05304	−64	0.593	2.530	1.544	5.481	4.—0.1386	1.3793	1.2407	90	181.8	1.650	0.6060	65.3	493.5	558.9	438.9	503.3	0.1238	0.8980	1.0218
−28	14.35	18.35	0.05449	−63	0.593	2.530	4.544	6.481	6.—0.1362	1.3744	1.2382	91	184.8	1.624	0.6158	66.5	492.5	559.1	437.9	503.5	0.1259	0.8945	1.0205
−27	14.76	17.87	0.05599	−61	8.592	5.530	7.543	7.481	9.—0.1338	1.3695	1.2357	92	187.8	1.598	0.6258	67.7	491.5	559.2	436.9	503.6	0.1281	0.8910	1.0191
−26	15.18	17.40	0.05747	−60	8.591	8.530	2.543	9.482	3.—0.1314	1.3647	1.2333	93	190.9	1.572	0.6359	68.9	490.5	559.4	435.9	503.8	0.1302	0.8876	1.0178
−25	15.61	16.95	0.05900	−59	8.591	1.531	3.542	1.482	3.—0.1290	1.3598	1.2309	94	194.1	1.548	0.6460	70.1	489.5	559.6	434.9	504.0	0.1323	0.8842	1.0165
−24	16.05	16.51	0.0606	−58	7.590	3.531	6.541	3.482	5.—0.1266	1.3550	1.2285	95	197.3	1.524	0.656	71.3	488.5	559.8	433.9	504.1	0.1344	0.8808	1.0152
−23	16.50	16.09	0.0622	−57	7.589	6.531	9.540	5.482	8.—0.1242	1.3502	1.2260	96	200.5	1.500	0.667	72.5	487.5	560.0	432.8	504.3	0.1365	0.8774	1.0139
−22	16.96	15.68	0.0638	−56	6.588	9.532	5.537	2.483	0.—0.1219	1.3454	1.2236	97	203.8	1.477	0.677	73.7	486.5	560.2	431.8	504.5	0.1387	0.8740	1.0127
−21	17.43	15.28	0.0654	−55	6.588	1.532	5.538	9.483	2.—0.1195	1.3407	1.2213	98	207.1	1.454	0.688	74.9	485.5	560.3	430.8	504.6	0.1408	0.8706	1.0114
−20	17.91	14.89	0.0671	−54	6.587	4.532	8.538	0.483	4.—0.1171	1.3360	1.2189	99	210.4	1.431	0.699	76.1	484.4	560.5	429.8	504.8	0.1429	0.8672	1.0101
−19	18.40	14.52	0.0689	−53	5.586	6.533	1.537	2.483	6.—0.1147	1.3313	1.2165	100	213.8	1.408	0.710	77.3	483.4	560.7	428.7	504.9	0.1450	0.8638	1.0088
−18	18.90	14.16	0.0706	−52	5.585	9.533	4.536	4.483	8.—0.1124	1.3266	1.2142	101	217.2	1.386	0.721	78.5	482.3	560.8	427.7	505.1	0.1471	0.8604	1.0075
−17	19.41	13.81	0.0724	−51	4.585	1.533	7.535	6.484	0.—0.1100	1.3219	1.2118	102	220.7	1.365	0.732	79.7	481.3	561.1	426.7	505.2	0.1493	0.8570	1.0063
−16	19.93	13.48	0.0742	−50	4.584	4.534	0.534	8.484	3.—0.1077	1.3172	1.2095	103	224.2	1.345	0.743	80.9	480.3	561.2	425.6	505.4	0.1514	0.8537	1.0051
−15	20.46	13.15	0.0760	−49	4.583	6.534	3.533	9.484	5.—0.1054	1.3126	1.2072	104	227.7	1.325	0.755	82.2	479.2	561.4	424.6	505.6	0.1535	0.8503	1.0039
−14	21.00	12.83	0.0779	−48	3.582	9.534	6.533	1.484	7.—0.1031	1.3080	1.2049	105	231.2	1.305	0.766	83.4	478.2	561.6	423.5	505.7	0.1557	0.8469	1.0026
−13	21.56	12.51	0.0799	−47	3.582	2.534	9.532	3.484	9.—0.1008	1.3034	1.2026	106	234.8	1.285	0.778	84.6	477.1	561.8	422.5	505.9	0.1578	0.8435	1.0014
−12	22.13	12.21	0.0819	−46	2.581	4.535	1.531	4.485	1.—0.0984	1.2987	1.2003	107	238.4	1.266	0.790	85.8	476.1	561.9	421.4	506.1	0.1599	0.8403	1.0002
−11	22.71	11.92	0.0839	−45	2.580	6.535	4.530	6.485	3.—0.0961	1.2941	1.1980	108	242.1	1.247	0.802	87.1	475.0	562.1	420.4	506.2	0.1621	0.8369	0.9990
−10	23.30	11.63	0.0860	−44	2.579	9.535	7.529	8.485	5.—0.0938	1.2896	1.1958	109	245.8	1.228	0.814	88.3	474.0	562.3	419.3	506.4	0.1642	0.8336	0.9978
−9	23.90	11.35	0.0881	−43	1.579	1.535	1.528	0.485	9.—0.0915	1.2851	1.1936	110	249.6	1.210	0.826	89.6	472.9	562.5	418.3	506.6	0.1664	0.8302	0.9966
−8	24.52	11.08	0.0903	−42	1.578	4.536	3.526	3.485	9.—0.0893	1.2806	1.1913	111	253.4	1.192	0.839	90.8	471.8	562.6	417.2	506.7	0.1686	0.8268	0.9954
−7	25.15	10.82	0.0924	−41	0.577	6.536	6.527	3.486	1.—0.0870	1.2761	1.1891	112	257.3	1.174	0.852	92.1	470.7	562.8	416.1	506.9	0.1707	0.8235	0.9942
−6	25.80	10.57	0.0946	−40	0.576	8.536	9.526	4.486	3.—0.0847	1.2716	1.1869	113	261.2	1.156	0.865	93.3	469.6	562.9	415.1	507.0	0.1729	0.8202	0.9930
−5	26.46	10.32	0.0969	−38	9.576	1.537	1.525	6.486	6.—0.0824	1.2671	1.1847	114	265.2	1.139	0.878	94.6	468.5	563.1	414.0	507.2	0.1751	0.8169	0.9919
−4	27.13	10.08	0.0992	−37	9.575	4.538	0.523	7.486	6.—0.0801	1.2626	1.1825	115	269.2	1.122	0.891	95.9	467.4	563.3	412.9	507.4	0.1772	0.8135	0.9907
−3	27.82	9.85	0.1015	−36	8.574	6.537	7.523	9.487	0.—0.0778	1.2582	1.1804	116	273.3	1.105	0.905	97.1	466.3	563.5	411.9	507.6	0.1794	0.8102	0.9896
−2	28.52	9.62	0.1039	−35	8.573	8.538	0.523	1.487	2.—0.0755	1.2537	1.1782	117	277.4	1.088	0.919	98.4	465.2	563.7	410.8	507.7	0.1816	0.8068	0.9884
−1	29.23	9.40	0.1064	−34	7.573	0.538	2.522	3.487	4.—0.0732	1.2493	1.1761	118	281.5	1.072	0.933	99.7	464.1	563.8	409.7	507.9	0.1838	0.8035	0.9873
0	29.95	9.19	0.1089	−33	7.572	2.538	5.521	4.487	6.—0.0709	1.2449	1.1740	119	285.7	1.057	0.946	101.0	463.0	564.0	408.6	508.1	0.1859	0.8002	0.9861
1	30.69	8.99	0.1089	−33	6.572	4.538	8.520	5.487	8.—0.0686	1.2405	1.1719	120	289.9	1.042	0.960	102.2	461.9	564.2	407.5	508.2	0.1881	0.7969	0.9850
2	31.44	8.78	0.1139	−31	6.570	7.539	1.519	7.488	0.—0.0663	1.2362	1.1699	121	294.2	1.027	0.974	103.5	460.8	564.4	406.4	508.4	0.1903	0.7936	0.9839
3	32.21	8.58	0.1165	−30	5.569	9.539	3.518	8.488	2.—0.0640	1.2318	1.1678	122	298.5	1.012	0.988	104.8	459.7	564.5	405.3	508.5	0.1925	0.7903	0.9828
4	32.99	8.38	0.1192	−29	5.569	2.539	0.517	9.488	4.—0.0617	1.2275	1.1658	123	302.8	1.002	1.002	106.1	458.5	564.6	404.2	508.7	0.1947	0.7870	0.9817
5	33.79	8.20	0.1219	−28	4.568	3.539	9.517	1.488	6.—0.0595	1.2231	1.1636	124	307.2	0.984	1.016	107.4	457.4	564.9	403.1	508.9	0.1968	0.7838	0.9806
6	34.60	8.02	0.1247	−27	4.567	5.540	1.516	3.488	7.—0.0572	1.2188	1.1615	125	311.6	0.970	1.031	108.7	456.3	565.0	402.0	509.1	0.1990	0.7805	0.9795
7	35.43	7.84	0.1275	−26	3.566	7.540	4.515	4.488	9.—0.0550	1.2143	1.1595	126	316.1	0.956	1.046	110.0	455.2	565.2	400.9	509.3	0.2012	0.7772	0.9784
8	36.28	7.67	0.1304	−25	3.565	9.540	6.514	5.489	1.—0.0527	1.2099	1.1574	127	320.6	0.942	1.061	111.3	454.0	565.3	399.8	509.4	0.2034	0.7739	0.9773
9	37.14	7.51	0.1333	−24	2.565	2.540	9.513	7.489	3.—0.0505	1.2059	1.1554	128	325.2	0.929	1.076	112.6	452.8	565.5	398.7	509.6	0.2056	0.7707	0.9763
10	38.02	7.34	0.1363	−23	2.564	4.541	2.512	9.489	5.—0.0483	1.2017	1.1534	129	329.9	0.916	1.092	114.0	451.7	565.7	397.6	509.8	0.2078	0.7674	0.9752
11	38.93	7.18	0.1393	−22	1.563	6.541	4.512	0.489	7.—0.0461	1.1975	1.1514	130	334.6	0.903	1.108	115.3	450.6	565.9	396.4	510.0	0.2100	0.7641	0.9741
12	39.84	7.02	0.1424	−21	1.562	8.541	7.511	2.489	9.—0.0439	1.1932	1.1494	131	339.4	0.890	1.124	116.6	449.4	566.0	395.3	510.1	0.2122	0.7609	0.9731
13	40.79	6.87	0.1455	−20	0.562	1.542	0.510	3.490	1.—0.0416	1.1890	1.1474	132	344.2	0.877	1.140	117.9	448.2	566.2	394.1	510.3	0.2144	0.7577	0.9720
14	41.71	6.72	0.1487	−19	0.561	2.542	2.509	4.490	3.—0.0394	1.1848	1.1454	133	349.0	0.865	1.156	119.3	447.0	566.4	393.0	510.5	0.2167	0.7543	0.9710
15	42.67	6.583	0.1519	−17	9.560	4.542	5.508	6.490	5.—0.0372	1.1806	1.1434	134	353.9	0.853	1.172	120.7	445.8	566.5	391.9	510.7	0.2189	0.7511	0.9700
16	43.65	6.443	0.1552	−16	8.559	6.542	7.507	7.490	0.—0.0350	1.1765	1.1415	135	358.8	0.841	1.189	122.0	444.7	566.7	390.7	510.8	0.2211	0.7478	0.9689
17	44.65	6.308	0.1585	−15	8.558	8.542	9.506	8.490	9.—0.0328	1.1723	1.1395	136	363.8	0.829	1.206	123.4	443.5	566.9	389.6	511.0	0.2234	0.7446	0.9679
18	45.67	6.176	0.1619	−14	7.558	0.543	2.506	0.491	0.—0.0306	1.1682	1.1376	137	368.9	0.817	1.224	124.7	442.3	567.0	388.4	511.2	0.2256	0.7413	0.9669
19	46.70	6.047	0.1654	−13	6.557	1.543	5.505	1.491	2.—0.0284	1.1640	1.1356	138	374.0	0.806	1.241	126.1	441.1	567.2	387.3	511.3	0.2278	0.7380	0.9658
20	47.75	5.920	0.1689	−12	6.556	3.543	7.504	2.491	4.—0.0263	1.1599	1.1337	139	379.2	0.795	1.258	127.4	439.9	567.3	386.1	511.5	0.2301	0.7347	0.9648
21	48.82	5.796	0.1725	−11	5.555	5.544	2.503	3.491	6.—0.0242	1.1558	1.1317	140	384.4	0.784	1.275	128.8	438.8	567.5	384.9	511.7	0.2323	0.7315	0.9638
22	49.91	5.676	0.1762	−10	4.554	7.544	4.502	4.491	8.—0.0218	1.1516	1.1298	141	389.7	0.773	1.293	130.2	437.6	567.7	383.8	511.8	0.2346	0.7282	0.9628
23	51.02	5.560	0.1799	−9	4.553	9.544	5.501	6.491	9.—0.0196	1.1475	1.1279	142	395.0	0.762	1.312	131.6	436.2	567.8	382.6	512.0	0.2368	0.7250	0.9618
24	52.15	5.447	0.1836	−8	3.553	1.544	7.500	7.492	1.—0.0174	1.1435	1.1260	143	400.4	0.751	1.331	133.0	435.0	567.9	381.4	512.2	0.2391	0.7217	0.9608
25	53.30	5.336	0.1874	−7	3.552	2.545	0.499	8.492	3.—0.0153	1.1395	1.1242	144	405.8	0.741	1.349	134.4	433.7	568.1	380.2	512.3	0.2414	0.7183	0.9598
26	54.47	5.228	0.1913	−6	2.551	4.545	2.498	9.492	5.—0.0131	1.1354	1.1225	145	411.3	0.731	1.368	135.8	432.5	568.3	379.0	512.5	0.2436	0.7151	0.9588
27	55.66	5.122	0.1953	−5	1.550	6.545	5.498	1.492	7.—0.0109	1.1314	1.1205	146	416.8	0.721	1.387	137.2	431.2	568.4	377.8	512.7	0.2459	0.7120	0.9578
28	56.87	5.019	0.1993	−4	1.549	8.545	7.497	2.492	9.—0.0087	1.1274	1.1187	147	422.4	0.711	1.406	138.6	430.0	568.6	376.6	512.9	0.2481	0.7088	0.9569
29	58.10	4.918	0.2034	−3	0.549	0.546	0.496	3.493	0.—0.0065	1.1234	1.1169	148	428.0	0.701	1.425	140.0	428.7	568.7	375.4	513.0	0.2504	0.7055	0.9559
30	59.35	4.820	0.2075	−2	9.548	1.546	2.495	4.493	2.—0.0044	1.1194	1.1150	149	433.7	0.692	1.445	141.5	427.4	568.9	374.2	513.3	0.2526	0.7023	0.9550
31	60.62	4.724	0.2117	−0	8.547	3.546	4.494	5.493	4.—0.0022	1.1154	1.1132	150	439.5	0.683	1.464	142.9	426.2	569.0	373.0	513.4	0.2550	0.6990	0.9540
32	61.91	4.631	0.2159	+ 0	3.546	5.546	7.493	6.493	6.—0.0000	1.1114	1.1114	151	469.1	0.638	1.567	150.1	419.7	569.8	366.9	514.4	0.2666	0.6828	0.9494
33	63.22	4.540	0.2203	+ 1	3.545	6.546	9.492	8.493	5.—0.0021	1.1075	1.1096	152	500.1	0.597	1.676	157.5	413.0	570.5	360.6	515.3	0.2754	0.6668	0.9449
34	64.55	4.451	0.2247	+ 2	2.544	8.547	0.489	9.493	9.—0.0043	1.1036	1.1079	153	532.8	0.559	1.789	165.6	406.0	571.6	354.0	516.3	0.2842	0.6502	0.9405
35	65.91	4.364	0.2292	3	5.543	9.547	4.491	0.494	1.	0.0065	1.0996	1.1061	170	566.6	0.522	1.915	172.9	399.1	572.0	347.6	517.2	0.3023	0.6339	0.9362
36	67.29	4.279	0.2337	4	6.543	1.547	6.490	1.494	3.	0.0087	1.0957	1.1043	175	602.2	0.489	2.045	180.9	391.8	572.7	340.8	518.2	0.3146	0.6174	0.9320
37	68.69	4.196	0.2384	5	6.542	2.547	8.489	2.494	5.	0.0108	1.0918	1.1026	180	639.5	0.458	2.183	189.0	384.3	573.4	333.9	519.2	0.3271	0.6009	0.9280
38	70.13	4.116	0.2432	6	7.541	4.548	3.488	3.494	6.	0.0129	1.0879	1.1008	185	678.4	0.429	2.330	197.5	376.6	574.0	326.8	520.2	0.3399	0.5842	0.9241
39	71.56	4.037	0.2478	7	8.540	5.548	4.487	4.494	7.	0.0150	1.0840	1.0990	190	719.0	0.402	2.488	206.2	368.7	574.9	319.4	521.3	0.3530	0.5673	0.9203
40	73.03	3.959	0.2526	8	9.539	7.548	5.486	5.495	0.	0.0173	1.0801	1.0974	195	761.4	0.376	2.660	215.2	360.2	575.4	311.8	522.3	0.3664	0.5502	0.9166
41	74.53	3.883	0.2575	10	0.538	8.548	8.485	5.495	2.	0.0194	1.0763	1.0957	200	805.6	0.352	2.84		351.	5	303.9		0.5328	
42	76.05	3.810	0.2625	11	1.537	9.549	0.484	7.495	3.	0.0216	1.0724	1.0940	205	851.7	0.330	3.03		342.	4	295.7		0.5152	
43	77.60	3.739	0.2675	12	2.537	1.549	2.483	7.495	5.	0.0237	1.0686	1.0923	210	902.6	0.309	3.24		332.	7	287.5		0.4971	
44	79.16	3.668	0.2727	13	3.536	2.549	4.482	8.495	7.	0.0259	1.0647	1.0906	215	949.6	0.

TABLE 2. SATURATED AMMONIA VAPOR. PRESSURE TABLE

Temp. deg. F.	Sp. vol. sat. vap. per lb., cu.ft. per lb.	Density vapor, lb. per cu.ft.	Heat content of liquid	Latent heat of evap.	Heat content of vapor	Internal Energy B.t.u. Evap.	Internal Energy B.t.u. Vapor	Entropy Liquid	Entropy Evap.	Entropy Vapor	Pressure, lb.	Temp. deg. F	Sp. vol. sat. vap. per lb., cu.ft. per lb.	Density vapor, lb. per cu.ft.	Heat content of liquid	Latent heat of evap.	Heat content of vapor	Internal Energy B.t.u. Evap.	Internal Energy B.t.u. Vapor	Entropy Liquid	Entropy Evap.	Entropy Vapor
—103.7	225.	0.0044	.....	644.6		603.0		1.8106														
— 87.1	117.	0.0085	.....	639.9		590.7		1.7016														
— 76.5	80.	0.0125	.....	636.9		582.7		1.6362														
— 68.5	61.	0.0164	.....	634.6		576.5		1.5896														
— 62.0	49.3	0.0203	—98.4	617.2	519.1	571.5	473.4	—0.2207	1.5522	1.3315												
— 56.6	41.6	0.0241	—92.5	613.5	521.1	567.3	474.9	—0.2070	1.5222	1.3152												
— 51.9	35.9	0.0279	—87.6	610.2	522.7	563.7	476.2	—0.1947	1.4964	1.3017												
— 47.6	31.6	0.0316	—83.2	607.3	524.1	560.4	477.2	—0.1840	1.4740	1.2900												
— 43.9	28.3	0.0353	—79.3	604.7	525.2	557.2	478.0	—0.1747	1.4540	1.2793												
— 40.4	25.75	0.0388	—75.7	602.2	526.4	554.6	478.8	—0.1661	1.4362	1.2701												
— 37.2	23.60	0.0424	—72.4	599.9	527.5	552.0	479.5	—0.1584	1.4201	1.2617												
— 34.3	21.75	0.0460	—69.4	597.8	528.4	549.6	480.2	—0.1513	1.4053	1.2540												
— 31.5	20.16	0.0496	—66.5	595.8	529.3	547.2	480.9	—0.1446	1.3916	1.2470												
— 28.9	18.79	0.0532	—63.8	593.9	530.1	545.4	481.5	—0.1384	1.3788	1.2404												
— 26.4	17.60	0.0568	—61.2	592.1	530.9	543.3	482.0	—0.1324	1.3668	1.2344												
— 24.1	16.56	0.0604	—58.8	590.4	531.6	541.4	482.5	—0.1268	1.3556	1.2288												
— 21.9	15.64	0.0639	—56.5	588.8	532.2	539.4	483.0	—0.1215	1.3450	1.2235												
— 19.8	14.82	0.0675	—54.4	587.3	532.9	537.9	483.4	—0.1165	1.3350	1.2185												
— 17.8	14.09	0.0710	—52.3	585.7	533.4	536.3	483.9	—0.1119	1.3256	1.2137	141	75.0	2.109	0.4741	48.3	507.8	556.0	458.8	500.9	0.0910	0.9505	1.0414
— 15.9	13.45	0.0744	—50.3	584.3	534.0	534.7	484.3	—0.1075	1.3167	1.2092	142	75.5	2.082	0.4804	48.5	507.4	555.9	458.4	500.7	0.0928	0.9456	1.0384
— 14.0	12.82	0.0780	—48.4	582.9	534.6	533.1	484.7	—0.1033	1.3081	1.2048	143	76.0	2.056	0.4865	48.7	507.0	555.7	458.0	500.5	0.0946	0.9407	1.0353
— 12.2	12.27	0.0815	—46.5	581.5	535.1	531.6	485.1	—0.0990	1.2998	1.2008	144	76.2	2.030	0.4926	48.9	506.7	555.6	457.6	500.3	0.0964	0.9358	1.0322
— 10.5	11.77	0.0850	—44.7	580.2	535.6	530.2	485.4	—0.0950	1.2919	1.1969	145	76.5	2.005	0.4987	49.1	506.4	555.5	457.2	500.1	0.0982	0.9309	1.0291
— 8.9	11.30	0.0885	—42.9	579.0	536.1	528.8	485.8	—0.0912	1.2843	1.1931	146	76.9	2.043	0.4895	50.0	506.3	556.4	457.1	501.2	0.0974	0.9310	1.0284
— 7.2	10.88	0.0919	—41.3	577.8	536.5	527.4	486.1	—0.0874	1.2770	1.1896	147	77.2	2.029	0.4934	50.5	506.0	556.4	456.8	501.2	0.0982	0.9273	1.0255
— 5.7	10.50	0.0953	—39.7	576.6	536.9	526.1	486.4	—0.0840	1.2700	1.1861	148	77.5	2.015	0.4963	50.9	505.6	556.5	456.4	501.3	0.0985	0.9235	1.0220
— 4.2	10.13	0.0988	—38.1	575.4	537.4	524.9	486.7	—0.0805	1.2633	1.1828	149	78.1	2.002	0.4995	51.3	505.4	556.7	456.0	501.4	0.0993	0.9196	1.0189
— 2.8	9.82	0.1022	—36.7	574.3	537.8	523.7	487.0	—0.0771	1.2568	1.1797	150	78.5	1.988	0.5029	51.8	505.1	556.9	455.7	501.6	0.1001	0.9158	1.0159
— 1.5	9.52	0.1050	—35.5	573.2	538.2	522.5	487.3	—0.0743	1.2507	1.1764	151	78.9	1.976	0.5060	52.3	504.4	556.7	449.9	501.5	0.1009	0.9120	1.0129
— 0.3	9.47	0.1056	—35 0	573.2	538.2	522.2	487.3	—0.0737	1.2496	1.1758	152	79.3	1.964	0.5092	52.7	504.0	556.8	449.5	501.6	0.1018	0.9082	1.0100
+ 0.4	9.17	0.1090	—33.6	571.9	538.7	521.2	487.6	—0.0708	1.2446	1.1735	153	79.6	1.952	0.5125	53.1	503.7	556.9	449.1	501.7	0.1026	0.9044	1.0070
1.4	8.90	0.1124	—32.2	571.1	539.1	520.2	487.8	—0.0677	1.2388	1.1711	154	80.0	1.940	0.5158	53.5	503.3	557.0	448.8	501.8	0.1034	0.9006	1.0040
2.8	8.64	0.1158	—30.8	570.1	539.5	519.1	488.1	—0.0648	1.2331	1.1683	155	80.4	1.928	0.5187	54.0	503.0	557.0	448.4	501.7	0.1043	0.9313	1.0347
4.2	8.39	0.1192	—29.5	569.1	539.9	518.0	488.4	—0.0617	1.2275	1.1657	156	80.8	1.916	0.5220	54.4	502.6	557.1	448.0	501.8	0.1052	0.9280	1.0332
5.6	8.15	0.1226	—28.2	568.1	540.3	516.8	488.6	—0.0588	1.2219	1.1630	157	81.2	1.904	0.5253	54.9	502.2	557.2	447.6	501.8	0.1060	0.9247	1.0307
6.9	7.92	0.1260	—26.9	567.1	540.7	515.8	488.9	—0.0561	1.2167	1.1606	158	81.5	1.892	0.5287	55.3	501.9	557.2	447.2	501.9	0.1068	0.9214	1.0282
6.7	7.7	0.1294	—25.6	566.2	540.6	514.8	489.1	—0.0533	1.2115	1.1581	159	81.9	1.880	0.5320	55.8	501.5	557.3	446.9	502.0	0.1076	0.9182	1.0258
8.0	7.52	0.1328	—24.4	565.3	540.9	513.8	489.3	—0.0508	1.2065	1.1557	160	82.3	1.868	0.5353	56.2	501.1	557.4	446.6	502.1	0.1084	0.9235	1.0317
9.3	7.36	0.1362	—23.2	564.4	541.2	512.8	489.6	—0.0483	1.2017	1.1534	161	82.7	1.857	0.5386	56.7	500.7	557.5	446.2	502.2	0.1092	0.9202	1.0294
10.7	7.16	0.1396	—22.0	563.5	541.5	511.9	489.7	—0.0458	1.1970	1.1512	162	83.0	1.846	0.5418	57.1	500.4	557.5	445.9	502.2	0.1100	0.9169	1.0269
12.2	6.960	0.1431	—20.8	562.6	541.8	511.0	489.9	—0.0433	1.1923	1.1490	163	83.4	1.835	0.5451	57.5	500.0	557.6	445.5	502.2	0.1108	0.9136	1.0244
13.3	6.824	0.1465	—19.7	561.7	542.0	510.0	490.1	—0.0409	1.1877	1.1468	164	83.8	1.824	0.5483	58.0	499.7	557.7	445.1	502.3	0.1116	0.9103	1.0219
14.4	6.668	0.1500	—18.6	560.9	542.3	509.1	490.3	—0.0386	1.1831	1.1446	165	84.1	1.814	0.5515	58.4	499.4	557.7	444.8	502.3	0.1124	0.9070	1.0194
15.4	6.520	0.1534	—17.5	560.0	542.5	508.2	490.5	—0.0363	1.1789	1.1426	166	84.5	1.803	0.5547	58.8	499.0	557.8	444.4	502.4	0.1132	0.9037	1.0169
16.4	6.379	0.1568	—16.4	559.2	542.8	507.3	490.7	—0.0341	1.1747	1.1406	167	84.9	1.793	0.5578	59.2	498.7	557.9	444.0	502.5	0.1140	0.9004	1.0144
17.4	6.247	0.1601	—15.3	558.4	543.1	506.4	490.9	—0.0319	1.1706	1.1387	168	85.3	1.783	0.5609	59.7	498.3	558.0	443.7	502.5	0.1148	0.8972	1.0120
18.4	6.120	0.1634	—14.3	557.6	543.3	505.6	491.1	—0.0296	1.1665	1.1369	169	85.6	1.773	0.5641	60.1	497.9	558.0	443.3	502.6	0.1156	0.8939	1.0095
19.4	5.999	0.1667	—13.3	556.8	543.6	504.8	491.4	—0.0275	1.1625	1.1349	170	86.0	1.763	0.5673	60.5	497.6	558.1	443.0	502.7	0.1164	0.8907	1.0071
20.3	5.883	0.1700	—12.3	556.0	543.8	504.0	491.6	—0.0255	1.1586	1.1331	171	86.3	1.753	0.5705	61.0	497.2	558.2	442.6	502.7	0.1172	0.8875	1.0047
21.2	5.772	0.1733	—11.3	555.3	544.0	503.1	491.8	—0.0235	1.1548	1.1313	172	86.7	1.743	0.5738	61.4	496.9	558.2	442.3	502.8	0.1180	0.8843	1.0023
22.1	5.665	0.1765	—10.3	554.6	544.3	502.3	491.9	—0.0216	1.1511	1.1296	173	87.0	1.733	0.5771	61.8	496.5	558.3	441.9	502.8	0.1188	0.8811	1.0000
23.0	5.562	0.1798	—9.3	553.9	544.5	501.5	491.9	—0.0196	1.1475	1.1279	174	87.3	1.723	0.5804	62.2	496.2	558.4	441.6	502.8	0.1196	0.8779	1.0975
23.9	5.463	0.1831	—8.4	553.2	544.7	500.8	492.1	—0.0177	1.1440	1.1263	175	87.7	1.713	0.5836	62.6	495.8	558.4	441.2	502.9	0.1204	0.8747	1.0951
24.8	5.367	0.1863	— 7.5	552.4	544.9	500.0	492.3	—0.0158	1.1405	1.1246	176	88.0	1.704	0.5869	63.0	495.5	558.5	440.9	503.0	0.1197	0.9047	1.0244
25.6	5.274	0.1896	— 6.6	551.7	545.1	499.3	492.4	—0.0139	1.1370	1.1231	177	88.4	1.694	0.5902	63.4	495.1	558.6	440.5	503.0	0.1204	0.9013	1.0217
26.4	5.184	0.1929	— 5.7	551.1	545.3	498.5	492.6	—0.0122	1.1337	1.1215	178	88.7	1.685	0.5935	63.8	494.8	558.6	440.2	503.1	0.1211	0.9024	1.0235
27.3	5.097	0.1962	— 4.8	550.4	545.5	497.8	492.7	—0.0103	1.1303	1.1200	179	89.1	1.676	0.5967	64.2	494.5	558.7	439.9	503.1	0.1218	0.9012	1.0231
28.2	5.012	0.1996	— 3.9	549.7	545.7	497.1	492.9	—0.0085	1.1270	1.1185	180	89.4	1.666	0.6000	64.6	494.1	558.8	439.5	503.2	0.1226	0.8980	1.0206
28.9	4.929	0.2029	— 3.0	549.0	545.9	496.4	493.0	—0.0067	1.1238	1.1171	181	89.7	1.656	0.6034	65.0	493.8	558.8	439.2	503.3	0.1233	0.8948	1.0182
29.7	4.848	0.2063	— 2.2	548.4	546.2	495.7	493.2	—0.0050	1.1206	1.1156	182	90.1	1.647	0.6068	65.4	493.4	558.8	438.8	503.3	0.1241	0.8876	1.0217
30.5	4.770	0.2097	— 1.3	547.7	546.3	495.0	493.3	—0.0033	1.1174	1.1141	183	90.4	1.637	0.6102	65.8	493.1	558.9	438.5	503.4	0.1248	0.8905	1.0183
31.3	4.695	0.2130	— 0.5	547.0	546.5	494.3	493.5	—0.0016	1.1143	1.1127	184	90.7	1.630	0.6135	66.2	492.8	559.0	438.2	503.4	0.1256	0.8873	1.0149
32.1	4.623	0.2163	+ 0.3	546.4	546.7	493.6	493.6	—0.0001	1.1113	1.1112	185	91.1	1.621	0.6168	66.6	492.4	559.0	437.8	503.5	0.1263	0.8842	1.0116
32.8	4.554	0.2196	1.1	545.8	546.9	493.0	493.7	0.0018	1.1082	1.1100	186	91.4	1.613	0.6200	67.0	492.1	559.1	437.5	503.5	0.1271	0.8811	1.0082
33.5	4.487	0.2229	1.9	545.1	547.1	492.2	493.9	0.0035	1.1052	1.1086	187	91.7	1.604	0.6233	67.4	491.8	559.2	437.2	503.6	0.1278	0.8780	1.0058
34.3	4.422	0.2262	2.7	544.5	547.2	491.6	494.0	0.0051	1.1022	1.1073	188	92.1	1.596	0.6266	67.8	491.5	559.3	436.8	503.6	0.1286	0.8749	1.0035
35.1	4.359	0.2294	3.5	543.8	547.4	490.9	494.1	0.0067	1.0993	1.1060	189	92.4	1.588	0.6298	68.2	491.2	559.3	436.5	503.7	0.1293	0.8718	1.0011
35.8	4.298	0.2327	4.3	543.2	547.5	490.3	494.3	0.0082	1.0965	1.1047	190	92.7	1.580	0.6331	68.6	490.9	559.4	436.2	503.8	0.1296	0.8886	1.0182
36.5	4.239	0.2360	5.1	542.6	547.7	489.6	494.4	0.0097	1.0938	1.1035	191	92.9	1.572	0.6362	68.9	490.5	559.4	435.9	503.8	0.1303	0.8875	1.0178
37.2	4.179	0.2394	5.8	542.0	547.9	489.0	494.5	0.0113	1.0910	1.1023	192	93.4	1.563	0.6395	69.3	490.1	559.5	435.5	503.9	0.1310	0.8843	1.0153
37.9	4.121	0.2427	6.6	541.4	548.1	488.4	494.7	0.0128	1.0882	1.1010	193	93.7	1.555	0.6428	69.7	489.8	559.5	435.2	503.9	0.1317	0.8853	1.0169
38.6	4.065	0.2461	7.4	540.7	548.3	487.7	494.8	0.0143	1.0855	1.0998	194	94.0	1.546	0.6461	70.1	489.5	559.6	434.9	504.0	0.1323	0.8832	1.0161
39.3	4.010	0.2494	8.1	540.2	548.4	487.1	494.9	0.0158	1.0828	1.0986	195	94.3	1.541	0.6492	70.5	489.2	559.7	434.5	504.0	0.1329	0.8802	1.0131
40.0	3.958	0.2527	8.9	539.6	548.6	486.5	495.0	0.0173	1.0801	1.0974	196	94.6	1.533	0.6524	70.8	488.8	559.7	434.2	504.1	0.1336	0.8771	1.0107
40.7	3.907	0.2560	9.6	539.0	548.8	485.8	495.2	0.0187	1.0775	1.0962	197	94.9	1.526	0.6554	71.2	488.4	559.8	433.8	504.2	0.1342	0.8811	1.0153
41.3	3.858	0.2593	10.3	538.5	549.0	485.3	495.2	0.0201	1.0750	1.0951	198	95.2	1.519	0.6584	71.6	488.0	559.9	433.4	504.3	0.1349	0.8780	1.0129
42.0	3.810	0.2626	11.0	537.9	549.0	484.7	495.3	0.0215	1.0725	1.0940	199	95.5	1.512	0.6614	71.9	487.6	559.9	433.0	504.3	0.1355	0.8748	1.0103
42.6	3.765	0.2656	11.7	537.4	549.1	484.1	495.4	0.0229	1.0701	1.0929	200	95.9	1.504	0.6645	72.3	487.2	560.0	432.7	504.4	0.1362	0.8718	1.0080
43.3	3.720	0.2688	12.4	536.8	549.3	483.5	495.5	0.0243	1.0675	1.0918	201	96.2	1.497	0.6675	72.7	486.8	560.1	432.3	504.4	0.1368	0.8687	1.0055
43.9	3.676	0.2720	13.1	536.3	549.4	482.9	495.7	0.0257	1.0650	1.0907	202	96.5	1.489	0.6707	73.1	486.4	560.2	431.9	504.5	0.1375	0.8656	1.0031
44.5	3.634	0.2753	13.8	535.8	549.5	482.3	495.8	0.0271	1.0626	1.0897	203	96.7	1.482	0.6737	73.4	486.0	560.3	431.5	504.6	0.1381	0.8626	1.0007
45.1	3.591	0.2785	14.5	535.2	549.7	481.8	495.9	0.0284	1.0602	1.0886	204	97.0	1.474	0.6769	73.8	485.6	560.4	431.1	504.6	0.1388	0.8596	1.0110
45.8	3.549	0.2818	15.2	534.6	549.8	481.2	496.0	0.0298	1.0579	1.0876	205	97.3	1.467	0.6801	74.2	485.2	560.5	430.7	504.7	0.1394	0.8565	1.0084
46.4	3.508	0.2851	15.9	534.1	550.0	480.6	496.1	0.0312	1.0556	1.0866	206	97.6	1.459	0.6833	74.6	484.8	560.6	430.3	504.8	0.1401	0.8535	1.0060
47.0	3.468	0.2884	16.5	533.6	550.1	480.1	496.2	0.0323	1.0533	1.0856	207	97.9	1.451	0.6865	75.0	484.4	560.6	429.9	504.8	0.1407	0.8504	1.0036
47.6	3.429	0.2917	17.2	533.1	550.2	479.5	496.3	0.0335	1.0512	1.0847	208	98.2	1.443	0.6897	75.4	484.0	560.7	429.5	504.9	0.1414	0.8474	1.0012
48.2	3.390	0.2950	17.8	532.5	550.4	478.9	496.4	0.0349	1.0487	1.0836	209	98.5	1.436	0.6929	75.8	483.6	560.8	429.1	504.9	0.1420	0.8443	0.9988
48.8	3.352	0.2983	18.5	532.0	550.5	478.4	496.5	0.0362	1.0464	1.0826	210	98.8	1.428	0.6961	76.2	483.2	560.9	428.7	505.0	0.1427	0.8413	0.9965
49.4	3.315	0.3017	19.1	531.5	550.6	477.9	496.6	0.0374	1.0442	1.0816	211	99.1	1.421	0.6993	76.6	482.8	561.0	428.3	505.1	0.1433	0.8383	0.9942
50.0	3.278	0.3051	19.8	531.0	550.8	477.3	496.7	0.0386	1.0420	1.0806	212	99.4	1.413	0.7025	77.0	482.4	561.1	427.9	505.2	0.1440	0.8353	0.9919
50.5	3.242	0.3085	20.4	530.5	550.9	476.8	496.8	0.0398	1.0399	1.0797	213	99.7	1.406	0.7057	77.4	482.0	561.2	427.5	505.3	0.1446	0.8323	0.9896
51.1	3.206	0.3119	21.0	530.0	551.0	476.3	496.9	0.0410	1.0378	1.0788	214	100.0	1.398	0.7089	77.8	481.6	561.3	427.1	505.4	0.1452	0.8293	0.9873
51.7	3.171	0.3153	21.7	529.5	551.1	475.8	497.0	0.0422	1.0357	1.0779	215	100.3	1.391	0.7121	78.2	481.2	561.4	426.7	505.5	0.1459	0.8263	0.9850
52.2	3.137	0.3187	22.3	529.0	551.2	475.3	497.1	0.0434	1.0336	1.0770	216	100.6	1.384	0.7153	78.6	480.8	561.5	426.3	505.6	0.1465	0.8233	0.9827
52.8	3.104	0.3221	22.9	528.4	551.3	474.7	497.2	0.0446	1.0315	1.0761	217	100.9	1.377	0.7185	79.0	480.4	561.6	425.9	505.7	0.1471	0.8203	0.9804
53.3	3.072	0.3255	23.5	528.0	551.5	474.1	497.3	0.0458	1.0294	1.0752	218	101.2	1.370	0.7217	79.4	480.0	561.7	425.5	505.8	0.1477	0.8173	0.9781
53.9	3.040	0.3289	24.1	527.5	551.6	473.6	497.4	0.0470	1.0273	1.0743	219	101.5	1.363	0.7249	79.8	479.6	561.8	425.1	505.9	0.1483	0.8143	0.9758
54.4	3.010	0.3323	24.7	527.0	551.7	473.2	497.5	0.0482	1.0253	1.0735	220	101.8	1.356	0.7281	80.2	479.2	561.9	424.7	505.9	0.1489	0.8113	0.9736
55.0	2.982	0.3357	25.3	526.5	551.8	472.7	497.6	0.0494	1.0233	1.0726	221	102.1	1.349	0.7313	80.6	478.8	562.0	424.3	506.0	0.1495	0.8083	0.9713
55.5	2.954	0.3391	25.9	526.1	552.0	472.3	497.7	0.0505	1.0213	1.0718	222	102.4	1.342	0.7345	81.0	478.4	562.1	423.9	506.1	0.1501	0.8053	0.9690
56.0	2.926	0.3426	26.5	525.6	552.1	471.8	497.7	0.0516	1.0193	1.0709	223	102.7	1.335	0.7377	81.4	478.0	562.2	423.5	506.2	0.1507	0.8023	0.9667
56.6	2.900	0.3460	27.1	525.1	552.2	471.3	497.8	0.0527	1.0174	1.0701	224	103.0	1.328	0.7409	81.8	477.6	562.3	423.1	506.3	0.1513	0.7993	0.9644
57.1	2.874	0.3494	27.7	524.6	552.3	470.8	497.9	0.0539	1.0154	1.0693	225	103.3	1.321	0.7441	82.2	477.2	562.4	422.7	506.4	0.1519	0.7963	0.9621
57.7	2.852	0.3528	28.2	524.2	552.4	470.4	498.0	0.0550	1.0135	1.0685	226	103.6	1.314	0.7473	82.6	476.8	562.5	422.3	506.5	0.1525	0.7933	0.9598
58.2	2.829	0.3562	28.8	523.7	552.5	469.8	498.1	0.0561	1.0116	1.0677	227	103.9	1.307	0.7505	83.0	476.4	562.6	421.9	506.6	0.1531	0.7903	0.9575
58.8	2.803	0.3596	29.3	523.3	552.7	469.4	498.1	0.0572	1.0097	1.0669	228	104.2	1.300	0.7537	83.4	476.0	562.7	421.5	506.7	0.1537	0.7873	0.9552
59.1	2.777	0.3601	29.9	522.8	552.8	468.9	498.2	0.0583	1.0078	1.0661	229	104.5	1.293	0.7569	83.8	475.6	562.8	421.1	506.8	0.1543	0.7843	0.9529
59.6	2.752	0.3634	30.4	522.4	552.8	468.4	498.3	0.0594	1.0060	1.0653	230	104.8	1.286	0.7601	84.2	475.2	562.9	420.7	506.9	0.1549	0.7813	0.9506
60.1	2.727	0.3667	31.0	521.9	552.9	467.9	498.4	0.0605	1.0042	1.0646	231	105.1	1.279	0.7633	84.6	474.8	563.0	420.3	507.0	0.1555	0.7783	0.9483
60.6	2.703	0.3700	31.5	521.5	553.0	467.5	498.5	0.0614	1.0024	1.0638	232	105.4	1.273	0.7665	85.0	474.4	563.1	419.9	507.1	0.1561	0.7753	0.9460
61.1	2.679	0.3733	32.0	521.0	553.1	467.0	498.6	0.0625	1.0005	1.0630	233	105.7	1.266	0.7697	85.4	474.0	563.2	419.5	507.2	0.1567	0.7723	0.9437
61.6	2.656	0.3765	32.6	520.6	553.2	466.5	498.6	0.0636	0.9987	1.0623	234	106.0	1.260	0.7729	85.8	473.6	563.3	419.1	507.3	0.1573	0.7693	0.9414
62.1	2.633	0.3798	33.2	520.1	553.3	466.1	498.7	0.0647	0.9950	1.0607	235	106.3	1.253	0.7761	86.2	473.2	563.4	418.7	507.4	0.1579	0.7663	0.9391
62.6	2.611	0.3831	33.7	519.7	553.4	465.6	498.8	0.0658	0.9932	1.0600	236	106.6	1.247	0.7793	86.6	472.8	563.5	418.3	507.5	0.1585	0.7633	0.9368
63.1	2.589	0.3863	34.3	519.2	553.5	465.1	498.9	0.0669	0.9915	1.0593	237	106.9	1.241	0.7825	87.0	472.4

urate experimental work may render necessary a slight evision of the value of the constants in the equations resented. Hence the tabular values resulting from the quations are not to be considered as final, but as best epresenting the present knowledge of the properties of mmonia.

Of the three tables reproduced, the first and second on pages 60 and 61 are for the saturated vapor of ammonia and give explicitly all of the properties that are ordinarily needed for use. Table 3 gives the thermal properties of liquid ammonia.

TABLE 3. THERMAL PROPERTIES OF LIQUID AMMONIA AT SATURATION PRESSURE

Temp. Deg. F.	Pressure Lb	Sp. Vol. Cu. Ft. per Lb.	Density Lb. per Cu.Ft.	144 Apv'	Heat Content
—110	0.758	0.02202	45.42	0.003	
—105	0.947	0.02211	45.23	0.004	
—100	1.176	0.02220	45.04	0.005	
— 95	1.450	0.02229	44.85	0.006	
— 90	1.778	0.02239	44.66	0.007	
— 85	2.167	0.02248	44.47	0.009	
— 80	2.626	0.02258	44.28	0.011	
— 75	3.164	0.02268	44.09	0.013	
— 70	3.791	0.02278	43.89	0.016	
— 65	4.518	0.02288	43.70	0.019	
— 60	5.358	0.02299	43.51	0.023	
— 55	6.324	0.02309	43.31	0.027	
— 50	7.43	0.02320	43.11	0.032	—85.67
— 45	8.69	0.02331	42.91	0.038	—80.49
— 40	10.12	0.02342	42.71	0.044	—75.31
— 35	11.74	0.02353	42.50	0.051	—70.13
— 30	13.56	0.02364	42.30	0.059	—64.94
— 25	15.61	0.02376	42.09	0.069	—59.75
— 20	17.91	0.02388	41.88	0.079	—54.56
— 15	20.46	0.02400	41.67	0.091	—49.36
— 10	23.30	0.02412	41.46	0.104	—44.15
— 5	26.46	0.02424	41.25	0.119	—38.92
0	29.95	0.02437	41.04	0.135	—33.68
5	33.79	0.02450	40.83	0.153	—28.43
10	38.02	0.02463	40.61	0.173	—23.17
15	42.67	0.02476	40.39	0.196	—17.89
20	47.75	0.02490	40.17	0.220	—12.59
25	53.30	0.02503	39.95	0.247	— 7.26
30	59.35	0.02518	39.72	0.277	— 1.90
35	65.91	0.02531	39.50	0.309	+ 3.48
40	73.03	0.02547	39.27	0.344	+ 8.88
45	80.75	0.02562	39.04	0.383	+14.32
50	89.1	0.02577	38.81	0.425	19.80
55	98.0	0.02593	38.57	0.471	25.31
60	107.7	0.02609	38.33	0.520	30.87
65	118.1	0.02626	38.09	0.574	36.48
70	129.2	0.02642	37.85	0.632	42.14
75	141.1	0.02660	37.60	0.70	47.84
80	153.9	0.02678	37.35	0.76	53.60
85	167.4	0.02696	37.10	0.84	59.43
90	181.8	0.02714	36.84	0.92	65.32
95	197.3	0.02734	36.58	1.00	71.28
100	213.8	0.02753	36.32	1.09	77.30
105	231.2	0.02774	36.06	1.19	83.39
110	249.6	0.02795	35.79	1.29	89.57
115	269.2	0.02816	35.51	1.40	95.85
120	289.9	0.02839	35.23	1.52	102.24
125	311.6	0.02862	34.95	1.65	108.73
130	334.6	0.02886	34.66	1.79	115.32
135	358.8	0.02910	34.36	1.93	122.02
140	384.4	0.02936	34.06	2.09	128.83
145	411.3	0.02963	33.76	2.26	135.78
150	439.5	0.0299	33.45	2.43	142.87
155	469.1	0.0302	33.13	2.62	150.11
160	500.1	0.0305	32.80	2.82	157.52
165	532.6	0.0308	32.47	3.04	165.11
170	566.6	0.0312	32.03	3.27	172.88
175	602.2	0.0315	31.8	3.51	180.85
180	639.5	0.0318	31.5	3.77	189.03
185	678.4	0.0322	31.1	4.05	197.45
190	719.0	0.0326	30.7	4.34	206.16
195	761.4	0.0330	30.3	4.65	215.18
200	805.6	0.0335	29.9	4.99	
205	851.7	0.0340	29.4	5.36	
210	899.7	0.0345	29.0	5.75	
215	949.6	0.0350	28.6	6.16	
220	1001.4	0.0355	28.2	6.59	
225	1055.3	0.0361	27.7	7.1	
230	1111.3	0.0368	27.2	7.6	
235	1169.5	0.0376	26.6	8.1	
240	1229.9	0.0384	26.0	8.7	
245	1292.5	0.0393	25.4	9.4	
250	1357.4	0.0404	24.8	10.2	
255	1424.7	0.0417	24.0	11.0	
260	1494.4	0.0435	23.0	12.0	
265	1566.6	0.0457	21.8	13.3	
270	1641.3	0.0500	20.0	15.2	
273.2	1690.0	0.0678	14.75	21.2	

In tables 1 and 3 the argument is the temperature. Since it is often convenient to be able to work roughly at very high and very low temperatures, these tables have been extended on the one hand to the critical point itself and on the other hand to —110 deg. F. However, since the data upon which the tables are based are not well known at these extreme temperatures, the values above 160 deg. and below about —40 deg. should not be used with too much confidence.

In Table 2 the argument is the pressure. The values above 500 lb. per sq.in., and those below 10 lb. per sq.in. are less certain than those lying between these pressures.

⁂

Ammonia to Charge a Compression Plant

The amount of ammonia required to charge a compression plant of a certain tonnage varies somewhat with each individual plant as it depends primarily on the operating pressures, the expansion surface per ton of refrigeration and somewhat on the general layout of the plant. The solution of a specific problem may be of interest.

Take a compressor of 13 tons capacity having a cylinder 7x18 in. and a speed of 70 r.p.m. The condenser is made up of double pipe 20 ft. long and 12 pipes high, the inside water pipe being 1¼ in. in diameter and the outside ammonia pipe 2 in. The brine cooler has double pipe 16 ft. long and 12 pipes high, consisting of a 2-in. inside brine pipe and a 3-in. outside ammonia pipe. Assume a receiver 7½ ft. long and 8 in. in diameter. Then determine the amount of ammonia in pounds required to fully charge the plant, the amount of ammonia for the high- and low-pressure sides, and the ammonia per foot of expansion piping.

A 13-ton compression system, including the refrigerating machine, ammonia condenser, ammonia receiver and the piping connecting these apparatus would require about 150 lb. of ammonia for the first charge. Of this quantity about 20 lb. is needed for the condenser, 50 lb. for the receiver and the balance for the refrigerating machine and the connecting piping. A double-pipe brine cooler of the dimensions given would require approximately 60 lb., making a total of 210 lb. for the system.

When the plant is fully charged and in operation the ammonia receiver should be about one-half full and in this condition will hold about 50 lb. of ammonia.

The quantity of ammonia required for a compression system varies with the size. A 5-ton refrigerating machine would take 20 lb. per ton and a 30-ton refrigerating machine about 10 lb. per ton. For 2-in., direct-expansion piping it is customary to figure 0.15 lb. per ft. of length, and 0.1 lb. per ft. of 1¼-in. pipe. In some plants a larger allowance per foot of piping is made, but the above figures may be safely taken for a plant operating under average conditions.

⁂

Ammonia in Brine

The presence of some ammonia in calcium chloride brine does not affect its use in freezing tanks unless the quantity of ammonia is so great that it will prevent the absorption in the brine of a sufficient quantity of calcium chloride for the density required. While the ammonia in the brine will slightly affect its freezing point, it will tend to lower the freezing point rather than raise it. Therefore, if the brine will dissolve sufficient calcium chloride to bring its density up to 90 deg. salometer or thereabouts it can be safely used. This can be tested out by filling a pail with the brine and adding calcium chloride sufficient to raise its density as above stated.

EDITORIALS

Condition of New Jersey's License Law

New Jersey's license law took effect on July 4, 1913, but it is doubtful whether the Steam Engineers' and Boiler Operators' License Bureau will be organized for some time, as the legislature failed to appropriate the necessary funds for carrying out the provisions of this law. The excuse for this is that the law was passed during the closing hours of a special session. For this reason no rules and regulations have been drawn up, and nothing definite can be accomplished until the appropriation is made. This it will be the legislature's duty to do immediately on convening at the next regular session.

The Commissioner of Labor has been advising owners and managers of the plants in which stationary engines or boilers are used to file a memorandum with his office, giving a list of all engineers and firemen who would be in their employ on July 4, 1913, and who would be entitled to licenses without examination as provided for in the law. It would materially assist the Commissioner of Labor if those who should furnish this information will do so promptly, addressing the Commissioner of Labor at Trenton, N. J. It will thus be possible for the Department of Labor to forward the necessary formal application blanks to such owners or managers as soon as the License Bureau is organized, and there should be no difficulty in having these applications sent out and returned within the sixty-day limit prescribed by the Act.

⁂

A Central-Station Mistake

If store current is cheaper than home-made, buy it; otherwise, make it yourself. This, in brief, is and always has been POWER's position on the isolated-plant-central-station question. There are enough who cannot have their own plants and must buy current to give the central stations plenty to do. They should stick to this field. It deserves more of their care and attention, but does not get them because it is business that cannot get away anyhow. It is neglected while every effort is turned on grabbing up all the isolated plants.

To see the avidity with which the central stations are going after the small plants one would think they were trying to stamp out a plague. If the health and police departments of our large cities were correspondingly enterprising, disease and crime would be fast disappearing.

It is all wrong for the central stations to try to close up the isolated plants that are operating economically. If they would be sincere in their reports on the justification of their service in any individual proposition the public would have more confidence in them and it would not be necessary to employ spellbinders as business solicitors.

When a central station goes so far as to offer to operate an isolated plant when it has lost hope of closing it, look out! The argument to the owner will be: "Your business is so and so, we would not attempt to tell you how to run it, but ours is making current and we can operate your own plant cheaper than you can."

The scheme is very insidious, for once inside the plant, and with every interest in seeing it shut down, the central station can hardly be expected to do otherwise than try to strengthen its plea to sell current by running the equipment at a disadvantage. If the central station does save money over the building's operation of its own plant it is mainly, if not almost entirely, in the labor item. With cheaper help, what is likely to happen? Repairs will be neglected, failures of the service will be more frequent, until, if the plan works out as it is meant to, the owner closes down his plant in disgust and buys the current.

Really, it is not half as clever as it at first appears, for it would be a rather stupid owner that would not see through the ruse. Further, the turn about from an argument to sell current, claiming that the plant cannot make it as cheap, to an offer to operate the plant, shows insincerity at once.

The sooner the central stations and all other such companies realize that "public service" means service *of* not *by* the public, the better it will be for all concerned. In other words, they should cling to the fundamental principle that they were created for the public, not the public for them.

⁂

Office-Building Power Plants

Time was, and that not so long ago, when, with scarcely an exception, the mechanical equipment of the office building was considered a necessary evil to be obtained as cheaply as possible and tucked away in obscure corners of a low-ceiling basement with indifferent provisions for ventilation, if any at all, and scant thought of providing for efficiency on the part of either the apparatus or the operators.

Lately, however, ideas in this direction have changed markedly and the best practice today is to lay out the plant with as much thought and effort toward reliability and efficiency as are used in the construction of any other type of plant no matter what its purpose.

The plant of the Otis building, described in this issue, is a case in point. When it is known that its design was supervised by a man who had had large experience in the operation of plants of this type and knew their shortcomings thoroughly, it is no great cause for wonder that especially careful provision was made for accessibility, proper ventilation and the recording of operating data, all rarities in steam plants of a few years ago.

Some may criticize the employment of such devices as air washers as unwarranted or extravagant, but it is doubtful if such criticism is justified. Clean air reduces the accumulation of dust, and humidified air increases personal comfort, especially in the winter time, and hence tends to increase human efficiency. Both of these ends are worth reasonable effort to attain.

Weighing and measuring devices for the systematic accumulation of operating data are coming to be considered almost vital and scarcely a new plant of any kind is erected now without such equipment.

Shipping Power-Plant Equipment

Why American manufacturers have to be continually cautioned to use more judgment and care in shipping goods, especially to the South American markets, seems strange. Competition is sufficiently keen, and surely enough business has been lost to awaken them to the realization that something is wrong.

The trouble is not usually with the design or construction of the equipment but with the manner in which it is shipped. It may be argued that goods are shipped and crated according to specifications, and that if commodities are received broken or deranged, it is the fault of the carriers. However true this may be, it is no consolation to the purchaser. He wants the goods to use. Naturally, those manufacturers whose goods are received so that they are ready to use when assembled, will get more orders than those whose goods are broken and deranged regardless of specifications as to shipping.

The secret of the success of the Germans and the French, and possibly the English, in the South American market is the key to the Americans' failure—poor crating. The successful manufacturers have had the foresight to send South American consignments in especially strong cases and in parts small enough to be readily handled with the tackle and carriers characteristic to those countries. Engines, generators and other machinery for mines, etc., located in mountainous districts must usually be conveyed by mule-back or taken over special highways built at considerable cost.

It may seem proper to ship delicate instruments, for example, Orsat apparatus, electrical meters, etc., in ordinarily heavy cases and with the usual amount of excelsior or other padding, but it is not. Cases and such are usually unloaded from the ships in rope slings and large, heavy cases are likely to crush the smaller ones and their contents when the sling load is landed on the pier. When breakage occurs it means that the engineer, who is anxious to complete an installation or thoroughly test equipment before he leaves it in hands not any too competent, must wait weeks for another instrument to replace the broken one or go home after doing his best under adverse circumstances. Conditions like this sometimes have a doubly injurious effect on Americans. The native owners become dissatisfied with the engineer as well as with the manufacturer.

The suggestion is sometimes heard that fragile or delicate instruments would be more certain to reach their destination safely if taken apart and the pieces packed in separate compartments in one case. This is unquestionably true, but unless competent men were available to assemble the instrument or machine, dissatisfaction would be as strong as ever.

American design and construction of power-plant equipment equals that of any other country. If we used proper methods of crating and shipping and gave thorough consideration to the facilities for handling equipment, no European nation should surpass us in supplying distant markets.

New Ammonia Tables

During late years the field of mechanical refrigeration has broadened. It has been applied to new uses, the machines and apparatus employed are being made larger and better and the total tonnage in refrigerating and ice-making output has had its annual increase. With its increasing importance an accurate knowledge of the properties of refrigerating fluids has become more urgent. For ammonia, the most important of these fluids, a number of tables based upon meager data of various authorities have been used. These tables, giving the properties of ammonia, differ and it is known that all of them contain inaccuracies. For ammonia at a certain pressure and temperature, the tables of Wood and Peabody, which have been considered standard in this country, give different values, and unless the authority is specifically stated in each case, there is opportunity for confusion. The two tables above mentioned appeared in about 1889. Since that time considerable experimental work has increased our knowledge on the properties of ammonia, but even now comparatively little is known, considering the importance of the subject.

For some time the Engineering Experiment Station of the University of Illinois has been doing some interesting work on ammonia. The investigation was undertaken with the object of collecting and correlating the various scattered experimental data. In the words of the investigators an attempt was made to reconcile these data by means of well known thermodynamic laws and principles so that the results may be consistent with each other; and to express the various properties by means of formulas from which tables and charts in English units may be prepared. How well their attempt has succeeded may be inferred from the tables presented in the refrigerating department of this number. Space was not available to give all of the tabular matter contained in the bulletin, an extended table on superheated ammonia vapor being omitted. The authors of the bulletin realized that the experimental data were not as complete as could be desired and that more accurate experimental work may render necessary a slight revision of the values of the constants in the equations used. This being the case the tabular values are not to be considered as final, but as best representing the present knowledge of the properties of ammonia.

It would appear that the tables are as accurate as the present state of the art will permit. At least they are more nearly correct than any of the tables now used, and have been compiled for every degree of temperature and pound of pressure far in excess of the ordinary working limits. They are the Marks and Davis steam tables for ammonia and in preference to a number of tables less accurate it would seem that their universal adoption would be only a matter of course.

Our Cartoon this week is a rather strong "story without words." And how typical of human nature it is that those who are having their enjoyment are rushing heedlessly past the man whose sacrifice of his own pleasure makes theirs possible. Another point is the irony of the title, "The Day of Rest," for there is little rest evident in either half of the picture. Those who can rest will not and because of them others cannot.

READERS WITH SOMETHING TO SAY

Compound-Engine Valve Did Not Operate

In a plant having four cross-compound Corliss condensing engines, one of the night assistant engineers notified the chief that he was ill and could not take his regular watch the coming night, so the chief was compelled to stand it with the aid of an oiler.

Things went smoothly until, at two o'clock in the morning, the lights began to grow dim. The chief hustled around to locate the cause. The engine was not quite up to speed. He found the valve-gear all right; looked over the surface condenser, which showed 27½ in. of vacuum —in fact, there was no apparent cause for the low voltage or three-quarter engine speed. Then the chief told the oiler to speed up another engine.

The troublesome engine was shut down and left for the day-shift assistants to discover the cause. They accidently found the key that fastened the valve stem to the bell crank on the floor.

Of course, the valve-gear would apparently be working all right. The only way to detect this fault would be to ascertain if the valve stem turned, something one would not ordinarily think of, as the arm was lifting and cutting off in a natural manner by turning on the valve stem.

A. C. WALDRON.

Revere, Mass.

Losses for Different CO_2 Percentages

The important factors which affect the operation of boilers are the quality of fuel, its clinkering tendencies, method of firing, draft, tightness of setting, radiation, cleanliness, etc.

Assume a plant consuming 25 tons of coal per day at a cost of $3 per ton and at the usual average of 8 per cent. CO_2. Referring to the table the loss is 34.5c. per ton. Increasing the CO_2 value to 12 per cent. reduces the loss to 14.4c. per ton, and a yearly saving of over $1500.

T. A. LEES.

Quincy, Mass.

CO_2 percent.	Fuel loss percent.	Cost of coal per ton — Loss in cents per ton																
		2.20	2.30	2.40	2.50	2.60	2.70	2.80	2.90	3.00	3.10	3.20	3.30	3.40	3.50	3.60	3.70	3.80	3.90	4.00
15	0.022	4.8	5.0	5.2	5.5	5.7	5.9	6.1	6.3	6.5	6.7	6.9	7.1	7.3	7.5	7.7	7.9	8.1	8.3	8.5
14	0.029	6.3	6.5	6.9	7.2	7.5	7.8	8.1	8.4	8.7	8.9	9.2	9.5	9.8	10.1	10.4	10.7	11.0	11.3	11.6
13	0.038	8.3	8.7	9.1	9.5	9.8	10.2	10.6	11.0	11.4	11.7	12.1	12.5	12.9	13.3	13.6	14.0	14.4	14.8	15.2
12	0.048	10.5	11.0	11.5	12.0	12.4	12.9	13.4	13.9	14.4	14.8	15.3	15.8	16.3	16.8	17.2	17.7	18.2	18.7	19.2
11	0.060	13.2	13.8	14.4	15.0	15.6	16.2	16.8	17.4	18.0	18.6	19.2	19.8	20.4	21.0	21.6	22.2	22.8	23.4	24.0
10	0.075	16.5	17.2	18.0	18.7	19.5	20.2	21.0	21.7	22.5	23.2	24.0	24.7	25.5	26.2	27.0	27.7	28.5	29.2	30.0
9	0.093	20.4	21.3	22.3	23.2	24.1	25.1	26.0	26.9	27.9	28.8	29.7	30.6	31.5	32.5	33.4	34.3	35.3	36.2	37.1
8	0.115	25.3	26.4	27.6	28.7	29.9	31.0	32.2	33.3	34.5	35.6	36.8	37.9	39.1	40.2	41.4	42.5	43.7	44.8	46.0
7	0.139	30.5	31.9	33.3	34.7	36.1	37.5	38.9	40.3	41.7	43.0	44.4	45.8	47.2	48.6	50.0	51.4	52.8	54.2	55.6
6	0.182	40.0	41.8	43.6	45.5	47.3	49.1	50.9	52.7	54.6	56.4	58.2	60.0	61.8	63.7	65.5	67.3	69.1	70.9	72.8
5	0.236	51.9	54.2	56.6	59.0	61.3	63.7	66.0	68.4	70.8	73.1	75.5	77.8	80.2	82.6	84.9	87.3	89.6	92.0	94.4
4	0.316	69.5	72.6	75.8	79.0	82.1	85.3	88.4	91.6	94.8	97.9	101.1	104.2	107.4	110.6	113.7	116.9	120	123.2	126.4

Perfect combustion is not a matter of mere dictation and will be found quite difficult to attain in everyday practice. The same draft is not always available at all boilers in the same room. All settings may not be in perfect order and numerous other difficulties are encountered which frequently are easily remedied and which are always well worth the attention if any improvement in efficiency results. To illustrate the value of attention to boiler operation, the following table is compiled, which shows the amount in money saved by improvement of furnace conditions. Showing the effect of boiler-room conditions in this way, it is felt that a better conception may be had of the value of careful and thoughtful consideration to boiler-room equipment.

Grinding Engine Shaft in Position

Recently I was consulted about a job in a plant where an engineer had allowed the main bearing of a Corliss simple condensing engine to run hot enough to take the babbitt metal from the quarter and the bottom boxes. The shaft had come in contact with the cast-iron shell of the quarter and bottom boxes and was cut to a depth of nearly $\frac{1}{16}$ in. in places. The engine was run in connection with a waterwheel and as the water was very low and the plant had orders calling for early deliveries, I was induced to try to hand dress the shaft and rebabbitt the boxes in position. This procedure, however, proved a failure as the cuts in the shafts sheared the babbitt out of the boxes in a few hours' run.

I then decided to do a good thorough job by grinding the shaft to a smooth surface. The bearing was 26 in. long and 36 in. in diameter. A 1-hp. portable electric grinder was ordered. A pattern was made for a false bearing which was bolted on the side of the main bearing to carry the shaft while grinding. The weight of the shaft and wheel was carried by two heavy screw jacks set under the lugs of the false bearing. The side thrust was also provided for by using screw jacks. The foundation stone projected far enough to set the two heavy jacks on and the side-aligning jack had a footing against a conveniently located brick wall.

It was necessary to remove the eccentrics as the temporary bearing occupied that space on the shaft covered by the eccentrics. The quarter and bottom boxes were left in the pillow block, being backed off so as not to come in contact with the shaft. This was done to catch and support the shaft should anything give way. A tool carriage from a lathe was clamped to the pillow block in an inverted position, with the cross-feed parallel to the axis of the shaft. A plate of cast iron was obtained, planed parallel, and three sets of holes drilled and tapped into it to fasten the grinder, thus making it possible to move the grinder without disturbing the rigging. This

provision was necessary as there was but a 9-in. cross-feed on the tool carriage of the lathe.

As we had no dynamo or electric connection to supply current to the grinder, we borrowed a small generating set for that purpose.

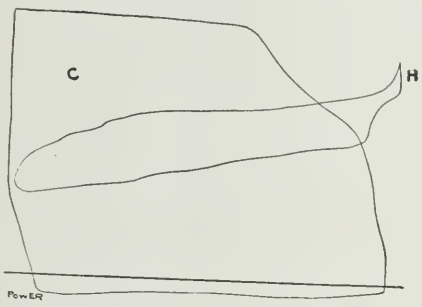
After assembling the outfit and turning the engine shaft for a short time, assuring ourselves that everything was solid and secure, we proceeded to grind the shaft. To drive the shaft the waterwheel gate was partly opened, leaving the engine clutch in, the connecting rod having previously been disconnected. We could in this way control the speed as desired. The shaft was ground until there were only two rings or cuts left in it, as it was not deemed wise to reduce the shaft any more than was necessary. The grinding attachment was then removed and the shaft was lightly filed and then stoned until a very high polish was obtained. In the meantime the boxes were taken out, rebabbitted, bored and scraped to the shaft. After assembling the engine and running light for about five hours, the full load was put on and no trouble whatever was experienced.

F. R. Pratt.

Adams, Mass.

Vacuum-Pump Diagrams for Comment

The accompanying diagrams were taken with a 50-lb. spring from the 8x16-in. steam end of a slide-valve vacuum pump, which makes 85 r.p.m., supplied with steam



Diagrams from Steam End of Vacuum Pump

at boiler pressure of 150 lb. I would like readers to state their opinions as to the probable cause for the imperfections of the diagram from the head end of the cylinder.

William I. Hart.

St. Louis, Mo.

Near Accident to Boiler

What might have resulted in a serious accident in a Western plant recently was averted by the engineer. The 100-hp. return-tubular boiler was erected by a building contractor when the building was built about four years ago.

The boiler was carried by hooks held on I-beams resting on top of a 24-in. side wall, as shown in Fig. 1. Loops were riveted to the shell into which were hooked 1⅛-in. hook bolts, shown in Fig. 2. A 2½-in. extra-heavy blow-off pipe was connected as shown. The engineer went to wash out the boiler and while the boiler was being emptied he decided to grind in the safety valve, which had been leaking. The valve was of the pop-type flange-jointed to the boiler near the rear end and also similarly jointed to a pipe leading outside the building.

As the space over the boiler was limited he decided to take the valve down to the work bench. On removing the last flange bolt the flanges sprang apart with considerable force.

After washing out and refilling the boiler and regrinding the safety valve the engineer started to replace the

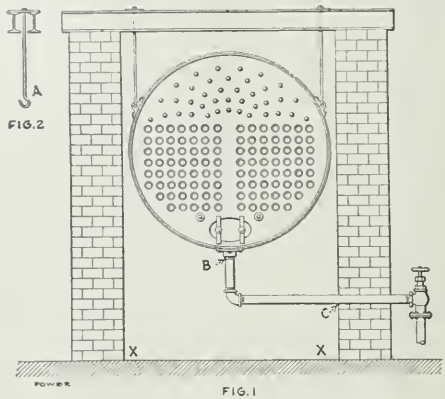


FIG.1

How the Boiler Was Supported

valve, but found the flanges would not meet nor could not be made to do so by springing the two ends of the pipes. While studying the situation his attention was attracted by the noise of running water. After opening the clean-out door to the combustion chamber and inserting a light, the blowoff pipe was found to be cracked at *B*. He immediately opened the blowoff valve and upon looking in alongside of the blowoff pipe found it was resting hard on the wall at *C*.

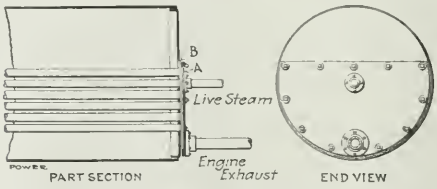
His curiosity now thoroughly aroused, he went on top with a hammer and sounding the suspension rods found them both loose. After removing some of the brickwork, both hooks were found broken at *A*, Fig. 2. The hook ends were found at *XX* in the combustion chamber. Heavy U-bolts were then used to suspend the boiler.

C. F. King.

Portland, Ore.

Old Boiler as Feed-Water Heater

An old boiler unsafe for commercial steam pressures was fitted up to serve as a feed-water heater. A piece of boiler plate *A* was flanged about 1 in. all around the



Part of Boiler Fitted for Heating Feed-Water

edges to form a head over the tube sheet very much as a condenser head appears on a surface condenser. After bolt holes had been drilled in the head plate, a gasket of thick rubber was placed between the head and the boiler

as at *B*. One of these heads was provided for each end of the boiler. The engine is piped to the head as shown and a small live-steam line is connected to the head to furnish steam when the engine is not running. The cost of converting the boiler into a heater did not exceed $30, and it gives entire satisfaction.

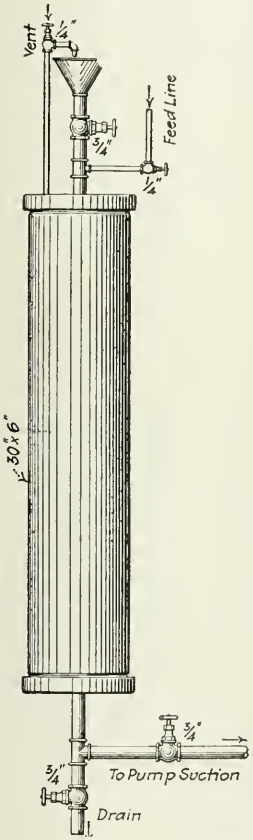
JAMES E. NOBLE.

London Junction, Ont., Canada.

Feeder for Boiler Graphite

This feeder is attached to the suction line of the boiler-feed pump on one side and the other is connected to the boiler-feed line or pressure side.

We mix a boiler compound and the graphite in a pail,



GRAPHITE FEEDER AND CONNECTIONS

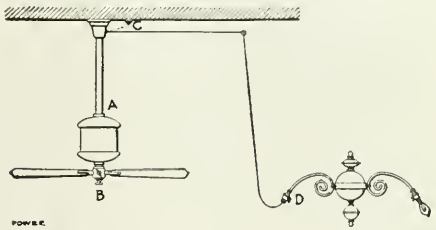
and pour this into the funnel after first draining the tank. To fill, pour the liquid into the funnel, venting the tank at the small ¼-in. line. When full, close the vent and the filling valve, crack the discharge valve to the pump-suction line, then open the filling valve in the line connected to the boiler-feed line filling the tank, which being under pressure, will discharge to the suction line as fast as wanted. By feeding through the suction the graphite goes through the pump. This greatly reduces the maintenance cost of the pump. The discharge can be made to last all day or be emptied in a few minutes.

ASA P. HYDE.

Binghampton, N. Y.

Emergency Repair to Fan Motor

An urgent request was made to operate one of the ceiling fans that was out of order. After being informed by the electrician of the absurdity of the request I decided that the fan must be made to run somehow. The



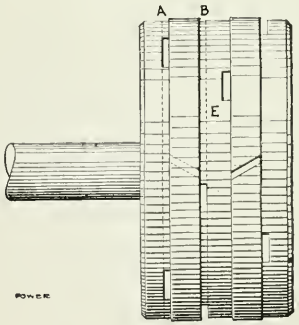
TEMPORARY CONNECTIONS FOR CEILING FAN

fan switch was located at the upper end of the shaft at *A* and was controlled by a rod running through the hollow shaft to the switch button at *B*. The switch was worn beyond repair and the difficulty was overcome by removing the defective switch and connecting the two field wires that formerly went to the switch, after which an extension was spliced to the lines leading to the ceiling socket at *C* and the plug was screwed in the lamp socket at the wall bracket at *D*. The fan was satisfactorily operated until a new switch was procured.

Brooklyn, N. Y. JAMES G. SHERIDAN.

Rings Cause Leaky Piston

The accompanying drawing shows how a leaky piston head was changed to one that would hold. This head had small openings cut on the sides of the ring grooves for the purpose of letting steam beneath the ring, but this steam would flow from the point *E* down beneath the ring



PISTON THAT LEAKED

and across, as shown. Consequently we had a constant leak across the piston. The grooves were widened, as shown by the dotted lines *AB* being turned out in the lathe and new rings fitted. Tfiis made the head tight.

Baltimore, Md. C. R. MCGAHEY.

ENGINEERS' STUDY COURSE

Making a Flue-Gas Analysis—Part IV

Starting where we left off in the last lesson, assume that the apparatus is connected with the gas supply. Connect the burette with the atmosphere by setting the three-way cock with the dot on the handle facing to the right. Then, place the leveling bottle on top of the cabinet and drive all the air out of the burette by opening the pinch cock *R*, Fig. 1, which is again repeated in this lesson, and allowing the water to run in until it reaches the 100-c.c. mark on the upper neck *H*. Now, turn the three-way cock so that the dot faces up, thus connecting the burette and gas supply. Lower the leveling bottle and release the

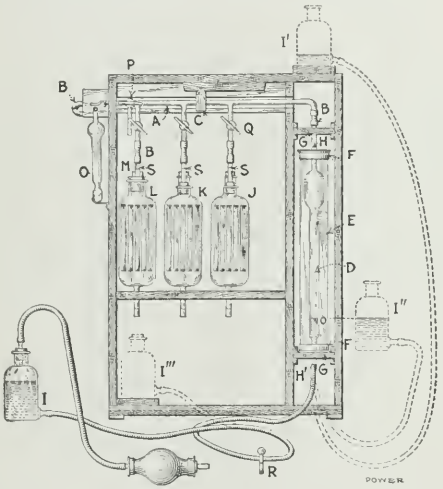


FIG. 1. DIAGRAM FOR ASSEMBLING ORSAT

pinch cock *R* entirely from the rubber connection. Then, connect the small hand pump to the leveling bottle in the manner shown in Fig. 1 and start pumping. If the gas is being drawn direct from the flue or chimney be sure that you pump long enough to secure a burette full of true gas. The amount of pumping required depends upon the length of the connection between the apparatus and the flue. After a little experience you will be able to tell just about how much pumping is required. Remember, however, it is far better to pump a little longer than is actually necessary than not to pump quite long enough. If the gas is being drawn from some kind of collecting apparatus, only a few strokes of the pump will be needed —say, a half dozen.

When you feel sure the burette is full of real gas, cease pumping and immediately give the three-way cock one-eighth turn to the right so that the handle is at 45 deg. and the dot is still on the upward side. Then, put the pinch cock on the leveling-bottle hose at about 6 in. from the burette end, disconnect the hand pump, and place the bottle on top of the cabinet. Now, open the three-way cock to the air by giving it another eighth turn to the right and by carefully releasing the pinch cock from the leveling-bottle hose, run the water into the burette to exactly the zero mark. If, by accident, you permit the water to rise above the zero mark, do not attempt to bring it back by means of the leveling bottle, for this would only let air into the burette and spoil the sample. If you wish, you can proceed with the analysis and make correction by calculation afterward, but I consider it better to simply expel all the gas and start over again. This avoids chance for error later and is about as quick as if you took the time to calculate the correction.

TESTING FOR CO_2

As soon as the water is brought up to the zero mark, close the three-way cock by giving it an eighth turn to the left, and open the cock *Q*, on the first pipette. Squeeze the pinch cock on the leveling-bottle hose and allow the water to rise in the burette to or nearly to the 100-c.c. mark. This forces the gas over into the pipette *J*, the gas driving the liquid from the front leg of the pipette into the back. All the little glass tubes in the front leg are now exposed to the gas and as they are dripping with the solution just driven out, they present a large wetted surface, and, hence, hasten the chemical action between the solution and the gas.

Allow the gas to remain in the pipette about one minute, then draw it back into the burette by lowering the leveling bottle and releasing the pinch cock, using care that none of the solution is drawn over with it. Repeat this operation about three times and then measure the gas as follows: Draw the solution in the pipette up to the mark *S* on the stem and close the cock *Q*. Then, release the leveling-bottle hose entirely from the pinch cock and make the water level in the burette and bottle equal by raising or lowering the bottle at the side of the cabinet as before described. Read the mark at which the water now stands in the burette. If, for instance, the water now stands at the 8.2-c.c. mark, the volume of the gas has diminished 8.2 c.c. in 100, or 8.2 per cent., and that is the percentage of CO_2 in the flue gas. The solution in the first pipette takes out (or absorbs) the CO_2, leaving the oxygen, carbon monoxide and nitrogen.

CHECKING RESULTS

After making the reading, run the gas into the pipette once more and take another reading as a check to make sure that all the CO_2 has been absorbed. If both readings are the same, all right. If not, make one more trial. When reading for CO_2 you should have no trouble in getting the first two readings to agree. If you do have trouble, your method may be wrong and it may be necessary to allow the gas to stand in the pipette a little longer each time or to increase the number of times you run it back and forth. Or, if the solution has been used a long time it may have become weak and need renewing.

A good thing to remember when running the gas from the burette into the pipette and *vice versa* is to watch the rising liquid, in this way eliminating the danger of running any liquid out of the vessel in which it belongs. Thus, when running the gas from the burette into the pipette, watch the water rise in the burette, stopping the flow before it shoots up through the neck *H*, and over through the header into the pipette. When running the gas back, watch the liquid rise in the front leg of the pipette and stop it before it reaches the burette.

Testing for Oxygen

After getting a check on the CO_2 reading, open the cock on pipette *K*, and run the gas back and forth in this pipette in exactly the same manner as before. Only, instead of running it in and out only four times, as in the case with the first pipette, the operation should be repeated about seven times before a reading is taken. The reason for this is that the solution for absorbing oxygen, the part of the flue gas absorbed in the second pipette, does not act as quickly as the solution used in the first pipette for absorbing CO_2.

Check the reading in the same manner as before by running the gas over once more and taking an extra reading. The difference between the new correct reading and the first correct reading gives the percentage of oxygen contained in the flue gas. For instance, if the new reading were 17.6 per cent. and the previous one had been 8.2 per cent., then the oxygen content in the flue gas would be

$$17.6 - 8.2 = 9.4 \textit{ per cent.}$$

Testing for CO

After obtaining a correct reading for the oxygen, open the cock on pipette *L* and go through the same process with this pipette as with the other two, only repeat the operation of running the gas back and forth about 11 times. The solution in this pipette absorbs any carbon monoxide (CO) that may be contained in the flue gas. Its action, however, is very slow and feeble and much care and patience must be used to get a correct reading.

The principle upon which the Orsat apparatus is based is that when certain chemical solutions are brought in contact with certain gases, the gases combine chemically with the solutions in such a way that they become a part of the solution. Ordinary flue gas consists principally of a mixture of carbon dioxide, oxygen and nitrogen and, sometimes, carbon monoxide, hydrogen and some hydrocarbons. When a given volume of such a mixture is brought in contact with a solution of caustic potash and water, the carbon dioxide combines with the caustic potash and forms a substance which becomes a part of the solution. The solution increases in volume but very slightly indeed—so slightly, in fact, that the increase may be entirely neglected in our work. But the volume of the flue gas has diminished by the amount of carbon dioxide it contained.

In a similar way the oxygen and the carbon monoxide disappear from the flue gas when brought into contact with the proper chemical solutions.

The solutions used in the Orsat must be employed in the order here given because the solution for carbon monoxide will absorb oxygen as well, and the solution for oxygen will absorb carbon dioxide, so the CO_2 must be taken out first, the oxygen second and the CO third.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

We rather missed the big noise of the Fourth of our younger days, and up to now we'd frown on the "safe and sane" idea. The big noise helped to bang out our appreciation for what was done at Concord, Lexington and Bunker Hill. But when "Collier's Weekly" told us that "in three years New York City yielded 1339 killed and wounded by fireworks," more than our losses in seven Revolutionary battles, it's the front stoop and the red and blue lights for ours; the clang of the ambulance would get on our nerves.

⁂

A Professor Emeritus (his name is really Wadsworth) of the University of Pittsburgh says slang is technical and necessary language. Engineer's plant talk, the mechanic's vernacular, baseball and prize-fight descriptions—what would it all mean divested of its slang? Hooray for the Prof. and on with the slang!

We acknowledge our indebtedness to "Coal Age," for this scintillating gem of thought; it didn't occur to us.

⁂

"Phenix," the New York Leather Belting Co.'s clever little magazine, has an article on "Love." It advocates love during business, but the object must be an "it," not a "she." Concentrated love is idealistic; you must have an ideal if you would love your work. We have known men who said they were wedded to their work, but they soon got a separation on the ground of incompatibility. Perhaps they leaned more heavily toward the "she" than the "it."

⁂

Overexciting food is responsible for the anarchical doctrines held by many, says a French sociologist. Can we no longer dash the "mulligan" in our suds? Must we eschew our hot dogs, our strenuous Limburger and our outspoken garlic? Is it for these table delicacies that we have anarchistic tendencies?

⁂

The incarcerated British militants may have mixed some of the aforementioned "overexciters" in order to give impetus to their anarchic doings. When jailed, they refused to eat and were forcibly fed through their noses. About four good sniffs of this ménu would either make 'em behave or place 'em beyond the good offices of even the pulmotor.

⁂

Unless you came 'way East, you chaps inland won't see much of the "Imperator." Next to seeing it, however, is to read about it on page 50 of this issue. This ship has pretty darn near everything for safety and comfort but a merry-go-round and a trolley line. And by the way, the Hamburg-American people pronounce it Im-pe-rah-tor, with the accent on the "rah."

⁂

Ever been lost in Perth Amboy? Don't do it. It happened recently to Hoboken Bill Reynolds, Jersey City Jack Callahan and those tender young things "Larry" Brannin, Ed Sears and All-Night Johnson, of Newark. After leaving the Perth Amboy Association meeting, the boys got separated. Bill and All-Night reached home; the others finally landed in the vicinity of the Rahway reformatory. Here they unearthed a hotel and waited for daylight. Some folks think Ed will be the next national conductor, but Cal and "Larry" say he'll never "conduct" them again unless he is armed with an automobile bluebook and a compass.

⁂

In one of Louis Tracy's recent novels an old sea captain, while cruising in the Red Sea, tells the passengers that they don't know what hot weather is. Says he: "Last summer our bunkers gave out six hours north of Perim. We removed the awnings, and then the sun kept up the head of steam in the boilers until we ran into Perim." Might paste this in your kelly to encourage you when the hot days set in.

⁂

First it was Efficiency who had the highest batting average; then he struck out for the bush. Now, it's Uplift who's banging the ball all over the industrial field. Funny, isn't it, how keen we are for a new peg on which to hang our fads and fancies? No matter what other name you call an onion, it's an onion just the same. And they all have their uses.

Functions and Design of Air Chambers

By Charles G. Richardson

SYNOPSIS—Size and location of air chambers, with suggestions on charging chambers with air.

To put the subject interrogatively: first, what is the purpose of air chambers? Second, what are the proper forms and dimensions?

Almost any engineer who has operated reciprocating pumps, large or small, will say that air chambers are for absorbing pulsations. Question him a little further and he will explain that pulsations is simply another word for water-hammer, which usually means blown-out gaskets and irregular pump action with consequent wear and tear on the working parts, and has been known to rupture main pipes or fittings with more or less serious consequences. He may even step over to the boiler-feed pump, open a little wider the cock on the water-pressure gage in the discharge pipe and give a demonstration of pulsations as shown by an oscillation of some 5 to 20 lb. of the dial hand.

For an answer to the second question we turn with confidence to a favorite engineering handbook, but are somewhat chagrined to find no data on the design of air chambers, even if the subject is mentioned at all. A search among borrowed handbooks produces the same result. A friend suggests, however, that air chambers form a regular part of the equipment supplied with pumps, and we hasten to the catalog file. Here some information is obtained; at least some pictures of air chambers are located. It seems rather strange that while the merits of the valves, valve seats, piston rods, plungers and cylinder jackets are all minutely emphasized, no mention is made of the air chamber which shows so conspicuously in the illustration. All shapes and sizes, graceful and otherwise, meet the eye not only in advertising matter, but on pumps in actual service.

FIG. 1

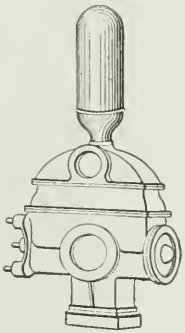


FIG. 2

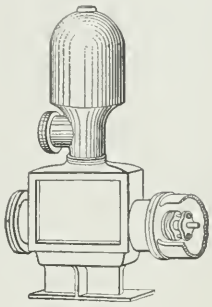


FIG. 3

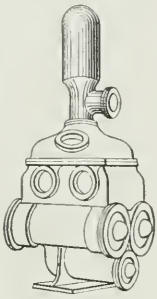


FIG. 4

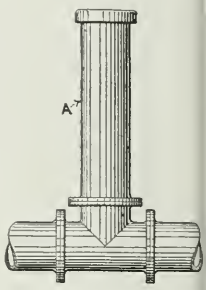


FIG. 5

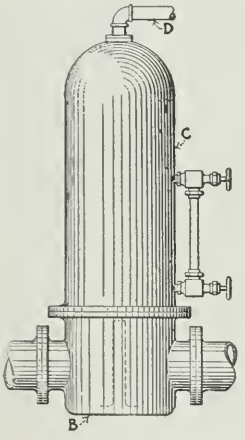


FIG. 6

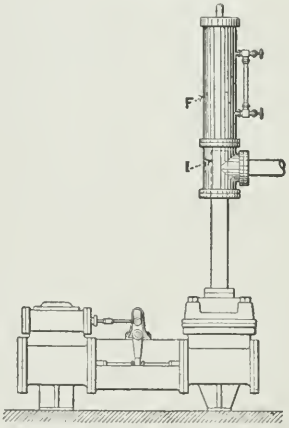


FIG. 7

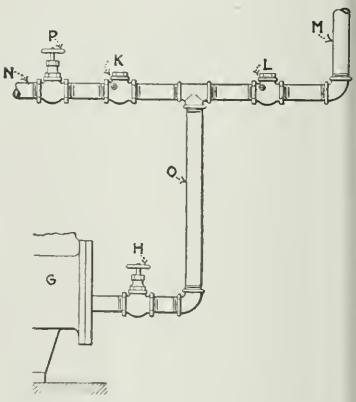


FIG. 8

POWER

The form and proportions of several commercial air chambers are shown by Figs. 1, 2, 3 and 4. Notice the extreme difference in individual ideas of the proper shape and size relative to the pump end. There seem to be two characteristics in common, a neck narrower than the upper portion and the entire absence of means for ascertaining whether the chamber contains any air whatever. Reluctantly it is concluded that reliable information on the subject of air chambers is not available.

This article presumes only to describe the essential features of the properly designed and properly located air chamber. Such conclusions as presented were obtained from repeated tests of equipment under actual operating conditions, chiefly in power plants, and they may serve as a guide for more exhaustive investigations.

Pulsations

To return to the matter of pulsations, it is not often recognized that there are two kinds; pulsations in pressure alone, and pulsations in pressure accompanied by pulsations in velocity. The former are found in the discharge lines of pumping engines on water-works' systems where the friction of several miles of pipe prevents the surging of the water with each stroke of the plungers: the latter is common to boiler-feed lines, which are comparatively short. Both kinds produce water-hammer. In the supply to boilers intermittent flow may also cause irregular boiler feeding and an improper action of automatic apparatus or flow meters depending for accuracy of operation upon a fairly uniform velocity of water. In either kind of pulsations an air chamber is often a necessity, and, if carefully installed, a money saver. The worst offender is the single-cylinder, single-acting pump. Boiler-feed pumps of this kind are occasionally found directly connected to a pumping engine and have a stroke of several feet. As they move slowly and pump water only upon the downward stroke of the plunger, the discharge is exceedingly intermittent. Single-cylinder, double-acting, duplex, triplex and quadruplex pumps follow in the order named. Air chambers are not always found necessary with the duplex pattern and rarely with the triplex. In fact, if the triplex pump is kept in good condition by renewing packings, valves, etc., promptly when needed, an air chamber will not be essential as the column of water in the discharge line is kept moving uniformly, even though the pump may be single acting. The tendency to use centrifugal pumps for boiler feeding and for other kinds of service in the power plant has become pronounced in late years and this type of pump is ideal for giving a steady flow entirely free from pulsations.

Placing the Air Chamber

Fig. 5 illustrates a common method of placing an air chamber in a pump-discharge line. Here *A* is the chamber proper, made from a piece of pipe and a cap, or often from a discarded casting of almost any shape which can be picked up around the plant. The criticism of this arrangement is that the capacity of the chamber is probably not great enough, the flow of the water is at right angles to the air space instead of directly against it as it should be to obtain the maximum cushioning effect, there is no means for determining whether any air is present and no way is provided for recharging the chamber with air when necessary. If it is absolutely necessary to place the air chamber directly in the main line a special casting *B*, Fig. 6, should be made, containing a vertical partition several inches higher than the main pipe connections. On the top of this special may be mounted another casting *C*, of the shape illustrated, or if preferred this top piece can be made up of pipe fittings similar to Fig. 5. A gage-glass should be attached to the lower end of *C*. There should also be a connection *D* of, say, ¼-in. pipe, for charging the air chamber when the gage-glass shows that the air has been partially absorbed. It will be noticed that the course of the water is directed by the baffle against the air space and then has to change its direction again before leaving the chamber.

It is usually possible, however, to locate the air chamber on a tee, as illustrated in Fig. 7. This is a less expensive and fully as effective an arrangement. All of the fittings may be made up from stock pipe and specials. It is essential that the discharge pipe from the pump be carried above the outlet from the tee, as shown at *I*, so that none of the water can pass the tee without coming in contact with the air space in the chamber *F*. This by-passing materially reduces the effectiveness of the air chambers shown in Figs. 1 to 4. It will be noticed that in Fig. 7 the essential features of Fig. 6 have been retained. If there is an objection to the use of a gage-glass, owing to high pressures, two gage-cocks might be employed. Air chambers, however, cannot often be placed in accessible locations and the use of gage-cocks is apt to lead to a falling off in attention.

Air Chamber a Flywheel

It is not often recognized that an air chamber should perform the same functions as the flywheel on an engine; that is, it should store up energy during the forward stroke of the pump and give it out when the pump is reversing. Otherwise, the flow of the water cannot be made uniform and the very purpose for which the chamber was installed is destroyed. In boiler feeding this means that the pressure in the air chamber, and, hence, in the feed line, must be maintained above the pressure in the boilers or else the check valves in the individual feed lines will prevent any water entering the boilers when the pump is reversing; 5 or 10 lb. excess pressure is all that is needed. If this pressure cannot be maintained uniformly by hand regulation, the pumps should be controlled by the ordinary pump governor depending for its action upon the pressure in the discharge line. A curious opposition toward maintaining this slight excess pressure in the feed line seems to exist among many operating engineers. One advanced the objection that the steam consumption would thus be seriously increased, a second figured out the square feet of surface in the heater and concluded that an additional 5 lb. per sq.in. on all this area would result in a wreck. At another plant a meter showed that opening wide the feed valves, which were normally kept "cracked," gave no increase in rate of water to the boilers, showing that the firemen were working under a misapprehension. One prominent Rhode Island electric-railway company keeps an excess pressure of 15 lb. in the feed line. As the chief engineer expresses it: "When the boilers need water I intend they shall get it without a moment's delay." At still another plant, investigation showed that the check-valve disks on every one of the boilers had worn away and dropped through the seats, due to the constant pounding of these valves from pulsations.

Charging Air Chambers

Regarding the charging of air chambers, many plants have compressed air at high pressure which can be connected permanently to the air chamber and used when the gage-glass shows it necessary. Often air can be shifted in through the pump suction by a little careful manipu-

lation of a small air valve connected to the pump-suction pipe. This air valve should be preferably of the needle-valve type so as to permit close regulation; otherwise the pump may become air-bound. A simple and effective method of using the pump itself to fill the air chamber is illustrated in Fig. 8, where G is the pump cylinder. P a regulating valve and K and L check valves. Pipe M leads to the air chamber and N is open to the atmosphere. By opening P a little a column of air may be drawn into the vertical riser O through the check valve K. When the pump plunger reverses, this air is driven out through check valve L into the air chamber. Pipe O should be at least 2 ft. long. Valve H is always kept open except when disconnections are made. This arrangement is not presented as new, as several engineers have independently thought of the same idea and are using it successfully. The control of the air inlet at P instead of at H is thought to be original, however, and this permits an unobstructed passageway between the pump cylinder and the air chamber, facilitating charging. If the water is taken by the pump from an open heater above, pipe O must be made of a length sufficient to place the check valves and the air inlet N above the water level in the heater. If this is not feasible, an air connection can be made directly to N from the compressed-air system, assuming that there is a pressure greater than that due to the head of water in the heaters so that air will be forced into pipe O upon the opening of the check valve K.

One interesting test was run under the following conditions: Single-cylinder, single-acting boiler-feed pump direct connected to a pumping engine; discharge line 2 in. in diameter and about 250 ft. long; water pumped into an open tank through throttling valve on the end of the discharge line; 10-in. by 10-ft. air chamber located in the discharge line close to the pump. An absolutely steady flow of water into the tank was obtained with the throttling valve partly closed, showing that the air chamber was absorbing the extreme pulsations from the type of pump used.

Air Chamber Dimensions

With the exception of the single-cylinder, single-acting direct-connected pump, which is not often found in power plants, and which is diminishing in favor, the dimensions of the air chamber should be sufficient to provide an air space from five to six times the displacement of one pump plunger. The size of discharge lines bears a fairly constant ratio to pump capacity and satisfactory results have been obtained from air chambers of the following dimensions:

Size of Discharge Line In.	Inside Dia. of Air Chamber, In.	Total Height of Air Chamber, Ft.
2	8	2
2½	8	2½
3	10	3
4	10	4
5	12	5
6	16	6

It will be noticed that the height in feet corresponds to the diameter of the line in inches. If there is not head room enough, the chamber may be reduced in height and increased in diameter, retaining the same volume and making the neck as large as the second column of the table.

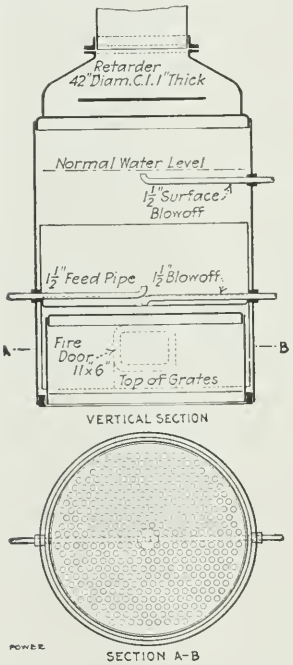
It is hoped that other contributions to this subject will follow as there is certainly great need for air-chamber standardization.

Small Vertical Boiler of High Capacity

By Charles F. Prescott

The writer was asked to install about 80 commercial boiler horsepower in a space only 7 ft. wide by 10 ft. long by 8 ft. 4 in. high. These dimensions were much too small for any usual type of boiler of such capacity.

The only type which looked at all feasible was the vertical, tubular, and as it is considered to be troublesome when of large size, the writer hesitated, but finally decided to build one for the work. The dimensions have been omitted in the illustration for the purpose of more clearly bringing out the fixtures adopted to secure a good circulation of the water and gases.



Showing General Construction of High-Capacity Boiler

The boiler was 72 in. outside diameter and 8 ft. 1½ in. high, and contained 366 two-inch tubes, 5 ft. 5½ in. between sheets, the heating surface of the firebox is 50.9 sq.ft., of the tubes below the water line 758.6 sq.ft., and above the water line, 287.5 sq.ft. Total evaporative heating surface 809.5 sq.ft. The grate surface is 23.22 sq.ft., giving a ratio of heating to grate surface 34.9 to 1.

To secure a rapid circulation of the water and offset the tendency of vertical boilers to accumulate scale on the crown-sheet, or the firebox, the writer devised the pan shown. This was made of steel plates, $\frac{3}{8}$ in. thick, the circular plate extending upward to a point 18 in. below the water line and downward to within 2½ in. of the mud ring.

The flat plate was drilled for the tubes using the firebox plate as a template and in addition to the tube holes,

ad a 7-in. hole in the center. The pan was set in the oiler with the flat plate 2½ in. above the crown-sheet nd held in place by the firebox stay-bolts which passed hrough the lower portion.

With this pan in position the circulation is strong, and positive as the intense heat from the firebox will cause the vater and steam to rise in the pan, pass rapidly across he crown-sheet and through the central opening, the downward flow being supplied from the top of the pan o the bottom of the boiler by the space between the an and the shell.

In addition to this natural action the boiler was supplied with feed water at the center by a pipe with the end upturned, so that whenever the pump was running he rapidity of the circulation was increased. The blow-off pipe was turned downward into the central opening and when used caused a flow of water from the firebox.

It will be noted that the tubes are laid off on triangles. In this case, this arrangement is not at all unfavorable as with a nozzle turned at 60 deg. on the end every row of tubes can be washed thoroughly. I have known this boiler to be in constant use for eleven weeks, using only the blowoffs for cleaning, and when opened there was a very small quantity of soft mud, mostly in the pan. No provision was made for washing the crown-sheet directly as the movement of the water was relied upon to keep it swept clean.

When first put in service there was no retarder in the hood and the firebox ends of the central tubes leaked badly. It was surmised that this was due to short-circuiting of the gases, causing most of the heat to go to the center. The retarder was suspended over the center tubes, brackets not shown, and no further trouble was experienced.

The draft was supplied by a stack 30 in. in diameter and 30 ft. high from the grates. The pressure carried was 125 lb. and the feed water was supplied at 155 deg. F. The coal used had an evaporative efficiency of 12½ lb. of water from and at 212 deg. F. Burning 370 lb. of coal per hour, the evaporation was 2920 lb. per hour from and at 212 deg. F., corresponding to 84.6 commercial horsepower.

Readers will find that some very important ratios are wrong in this boiler, when compared to good practice. The boiler would have been a failure had it not been for the circulating pan, which not only kept the heating surfaces clean, but by rapid movements of the water increased the capacity of those surfaces.

There is no doubt that the retarder did its share. The steam averaged 98 per cent. dry. To clean the flues we threw salt on the fire.

Ohio Boiler-Inspection Rules

In compliance with the recently amended Ohio steam-boiler-inspection law, the Ohio Board of Boiler Rules held a special meeting at the State House, Columbus, on July 7.

The purposes of the meeting were to formulate rules covering the construction and inspection of locomotive boilers installed and operated in the state which are not subject to inspection under the Federal laws; to formulate rules governing the construction of furnace flues in internally fired boilers; to revise the safety-valve rules to meet the requirements of modern steam-boiler practice.

Chairman C. H. Wirmel, of the state board, published an announcement of the above object of the meeting as required by law. An early issue of "Power" will contain the report of the proceedings.

Why the Chicago Federal Building Is To Have Its Own Plant

So much prominence has been given to the decision of the present administration to have the Chicago Federal Building furnish its own electric current, that the following history of the events leading up to it may be of interest.

The first important move was the investigation by Government engineers to ascertain whether or not an isolated plant would pay. Their report was rendered in July of last year and showed that the current was being purchased on a sliding scale that made its average cost 1.9c. per kw.-hr. It was estimated that with its own plant the building could be supplied with current at a cost of not to exceed 1.1c. per kw.-hr. The building already contained a plant for steam heating and the boiler equipment would not have to be increased. The help employed now numbering 22 men would have to be increased by only four men and the additional cost for labor would be less than 17½ per cent.

Where, for the heating, there had been consumed about 5600 tons of coal per year, it was figured that 2100 tons more would supply lighting and elevator power as well, the exhaust steam being used for heating. This was based on generating as much current as has been used per year recently, about 1,373,000 kw.-hr. and coal costing $3.15 a ton.

The report recommended the installation of a plant consisting of two 200-kw. and two 100-kw. generating sets and estimated that the saving would pay for the investment in three years.

Before bids were asked the central station was advised that an installation was contemplated and asked to make its best proposition on continuing to furnish current. It replied that the rate then (1.9c. per kw.-hr.) was the best it could make. Nevertheless about the time the bids were opened it offered to reduce the rate. This offer was considered and rejected. The central station then criticised the estimated cost for the building to furnish its own current as inaccurate, claiming that the current could not be made at so low a price.

Comparison of the costs at other Government buildings furnishing their own current showed all to be below the rate offered by the central station. To be sure the estimate was not too low it was checked by engineers in other Government departments and confirmed.

Negotiations became so complicated that no decision was reached during the last administration and it was passed on to the present one. It was not until April that any important new developments occurred. The last proposal of the central station was rejected as it was still above the estimated cost of the current generated in the building's own plant, and Secretary McAdoo ordered the contract awarded to the Harrisburg Foundry & Machine Works, which was low bidder on the basis of an evaluated guarantee.

The clause in the specifications by which the bids were compared is an interesting one and is in effect the same as has been incorporated in similar bids for the last year or so. It gives the Government the chance to close with the most favorable bid rather than as heretofore taking the lowest bid irrespective of value received as a whole. It follows:

COMPARISON OF BIDS—No bids will be considered upon apparatus having a greater steam consumption for the combined units than the amounts hereinafter specified under the heading "Steam Consumption," and in case the guaranties of various bidders differ they will be evaluated as follows for the purpose of comparison:

Cost to generate steam 16 (sixteen) cents per thousand pounds, and steam consumption guaranties will be evaluated at this rate. Each unit will be assumed to operate 8 hours a day, 365 days per year, and at the following load factor:

Percentage of load, per cent...	25	50	75	100	125	
Load factor, per cent	10	20	50	15	5	

The algebraic sum of the savings at various loads when operating under conditions given above will represent the gross savings per year effected by the units with the lower steam consumption over the units with the higher guaranties.

If the gross yearly savings as computed above exceeds 10 per cent. depreciation and 3 per cent. interest charges on the difference between the amount of the bids, the bid for the units with the lower steam consumption will take preference in the award over the bid for the units with the higher guaranties.

Should the successful bidder fail to fulfill his contract guarantee, the Government is protected by the following clause:

PENALTY—It must be distinctly understood to be one of the conditions under which bids are submitted for the work embraced in the specification that the engines and generators will meet every requirement of the specifications and the guaranteed amounts for steam consumption named by the bidder, under which conditions the contract price will be paid. In event the units fail to meet the specification requirements or the steam consumption is greater than that guaranteed by bidder, the department shall have the right to reject the unit or units absolutely and require the supply of satisfactory unit or units which shall comply with all contract requirements in

regard thereto; or if it elects to accept same in event steam consumption, at any load, is greater irrespective of other loads than that named in the proposal, then the contract price shall be the amount named in the contract for a satisfactory plant less the amount of deficiencies shown by test based on the following schedule for each pound or fractional part of a pound of steam per kilowatt-hour:

	Load				
	25 per cent.	50 per cent.	75 per cent.	100 per cent.	125 per cent.
100-kilowatt-hour unit	$30	$120	$420	$180	$75
200-kilowatt-hour unit	60	240	840	360	150

In the estimate the total cost of operating the plant for the production of current was calculated at somewhat less than $15,000 per annum, which would be a saving of some $11,000 over the cost of purchased current. On the basis of the contractor's guarantee it is likely that this saving will be considerably exceeded.

German Excursion of the American Society of Mechanical Engineers

Upon the invitation of the Verein Deutscher Ingenieure some 250 members and guests of the American Society of Mechanical Engineers left New York on the "Victoria Luise," of the Hamburg-American Line to attend the annual meeting of the Germany Society at Leipzig and to visit, under the auspices of that society, a number of the cities and industrial establishments of Germany. The first stage of the trip ended with the arrival of the steamer at Plymouth, England, one week after leaving New York.

The trip was exceptionally quiet as regards sea and weather, affording the fullest opportunity for the enjoyment of the program provided by the entertainment committee. Every hour was fully occupied; the principal evening events being:

Wednesday—Reception by the officers of the S.S. "Victoria Luise" and of the Society, followed by a dance.

Thursday—Lecture on German history by Henry Hess.

Friday—Mock trial.

Saturday—Lecture on German art by Prof. H. E. Clifford.

Monday—Lecture on German cities by W. R. Warner.

Tuesday—Cotillion.

Wednesday—Lecture on German educational system by Prof. C. R. Richards, and a cabaret performance.

In addition to these main events there were sports, games and contests of various sorts. On Sunday evening, the twenty-fifth anniversary of the accession of the present ruler, Emperor Wilhelm II, a special dinner was served at which the captain proposed the health of the Kaiser, and Dr. William H. Carpenter, vice-president of Columbia University, and president of the Germanistic Society of America, made appropriate remarks. On the following evening a special dinner was given to the Society and on Tuesday evening a farewell dinner to those who were to leave at Plymouth.

The company included engineers from all sections of the United States, representing all branches of engineering and by no means the least profitable of the advantages of the voyage were the impromptu discussions, not programmed, but always in order and in process in every saloon and upon every deck.

Representatives of the Verein met the boat at Cherbourg and the land program commenced at Hamburg, where the party arrived late on Thursday.

NEW PUBLICATIONS

RESUSCITATION. By Dr. Chas. A. Lauffer, Medical Director, Westinghouse Electric & Mfg. Co., East Pittsburgh, Penn. Published by John Wiley & Sons, New York. Size, 4x6½ in.; 47 pages, illustrated, cloth.

This book includes a reprint of a paper on this subject delivered by the author before the Philadelphia Section of the National Electric Light Association. The author, after explaining a number of successful results which have been obtained from employing resuscitation methods on men who were supposedly dead, gives a clear description of the mechanism of respiration, illustrating it by a number of views of the various parts of the anatomy.

The prone pressure, or Schafer method of resuscitation, which has been adopted by the National Electric Light Association, and a number of other engineering societies, is described in detail.

This book emphasizes the need of having the general public acquainted with the principles of resuscitation, and clearly shows how they can be learned so as to prove of valuable assistance to persons in the ordinary walks of life.

PERSONALS

B. F. Wilcox, formerly an operating engineer in the Public Service Corporation plant, at Marion, Jersey City, N. J., has been appointed chief engineer of that company's Trenton plant.

Albert Sheather, assistant chief engineer of the Public Service Corporation power plant, Elizabeth, N. J., has been awarded the gold watch fob offered by the state educational committee, N. A. S. E., of New Jersey, for having given the most correct answers to the 63 questions recently asked by that committee. Mr. Sheather is an officer of Elizabeth Association No. 14.

TRADE CATALOGS

Detroit Lubricator Co., Detroit, Mich. Catalog No. 36L. Locomotive lubricators. Illustrated, 56 pages, 5x8 inches.

De Laval Steam Turbine Co., Trenton, N. J. Catalog C. Steam turbines, velocity-stage type. Illustrated, 108 pages, 6x9 inches.

Henry R. Worthington, 115 Broadway, New York. Bulletin No. 202. Volute centrifugal pumps. Illustrated, 62 pages, 6x9 inches.

The Leavitt Machine Co., Orange, Mass. Catalog No. 16. Improved Dexter valve reseating machine. Illustrated, 28 pages, 7½x9 inches.

Sprague Electric Co., 527-31 W. 34th St., New York. Catalog No. 521. Flexible steel-armored hose. Illustrated, 16 pages, 5¾x8 inches.

Chicago Pneumatic Tool Co., Fisher Building, Chicago, Ill. Bulletin No. 127. Pneumatic drills, reamers, flue rolling and tapping machines, etc. Illustrated, 40 pages, 6x9 inches.

Sullivan Machinery Co., 122 S. Michigan Ave., Chicago, Ill. Bulletin No. 58-M. Cross compound power-driven air compressors. Illustrated, 20 pages, 6x9 inches. Booklet No. 112. Air compressors. Illustrated, 32 pages, 3x5½ inches.

The Smooth-On Mfg. Co., 572-574 Communipaw Ave., Jersey City, N. J., has just issued a helpful 16-page booklet, "Extracts from Smooth-On Instruction Book No. 12," which anyone interested in economical power-plant repair work can have by writing to the company.

The Nicholson File Co., Proxidence, R. I., has just published the eighth edition of "File Filosophy"—"a 49 years' education on files in an hour." "File Filosophy" is a handsome booklet full of helpful file information—in fact it is used as a textbook in many colleges, manual training schools, etc. It is sent free on request.

BUSINESS ITEMS

The firm of Barrett & Walsh Co., in the Chamber of Commerce Building, Detroit, are conducting their business under the name of the Power Plant Supply Co., with James E. Walsh as manager. Among others the company represents the Wm. B. Pierce Co., G. L. Simonds & Co., Laclede Christy Clay Products Co., Martin Grate Co and Bonner & Barnewall.

Wm. B. Merrill & Co., manufacturers of the well known Tripp metallic packing, having found their Boston plant too small to handle the growing demands for this packing, have moved to Jamaica Plain, a suburb of Boston. They now occupy the entire brick and concrete building recently built by the Lenox Automobile Co., where they have ample room and facilities for handling their rapidly growing business.

The American Engineering Co., Philadelphia, has recently secured orders for "Taylor" stokers from the New York, New Haven & Hartford R.R. Co., Cos Cob Conn.; the Narragansett Brewing Co., Providence, R. I.; the General Electric Co., West Lynn, Mass.; the Boston Woven Hose & Rubber Co., Boston, Mass.; the Dominion Iron & Steel Co., Sydney, N. C.; the American Brass Co., Waterbury, Conn.; the Bay State Street Ry. Co., Chelsea, Mass.; the Tremont & Suffolk Mills, Lowell, Mass.; the Cochrane Chemical Co., Boston, Mass.; the Montreal Electric Light & Power Co., Montreal, Canada; the United Illuminating Co., New Haven and Bridgeport; the Detroit Edison Co., Detroit, Mich.; the Philadelphia Electric Co., Philadelphia, Penn.; The Elmira Wafer, Light & R.R. Co., Elmira, N. Y.

POWER

Vol. 38 NEW YORK, JULY 15, 1913 No. 3

THE EXAMINER'S FUNCTION

Mixed-Pressure Turbo-Generator Installation

By T. W. Reed

SYNOPSIS—As a result of installing a mixed-pressure steam turbine, 300 kw. additional capacity was obtained from exhaust steam which had previously been exhausted to the atmosphere. This gain was obtained without additional labor or operating costs.

By installing a turbo-generator in the power plant of Arbuckle Brothers, sugar refiners and coffee roasters, it has again been proved that great advantage is derived from the use of this type of turbine in the industrial plant as a recoverer of waste steam, thus increasing the generating capacity without increasing the coal consumption and obtaining improved overall plant economy.

This power plant is located on the Brooklyn side of the East River and on the water front, a short distance north of the Brooklyn Bridge. During the year 1912, it was deemed advisable to increase the maximum capacity of the plant, and, at the same time, always have a spare unit in reserve. After careful consideration by the purchaser's engineers as to the best method of increasing the capacity and to determine what economies could be effected, a turbo-generator was recommended and purchased.

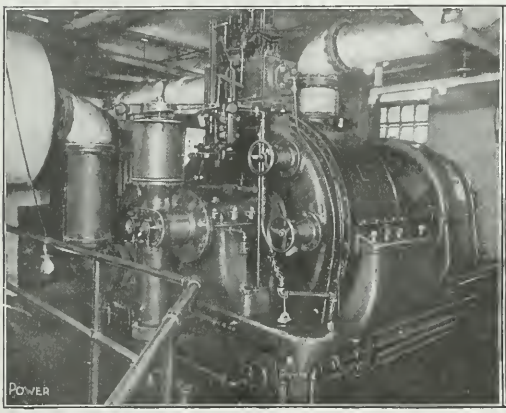


Fig. 1. Steam End of Mixed-Pressure Unit

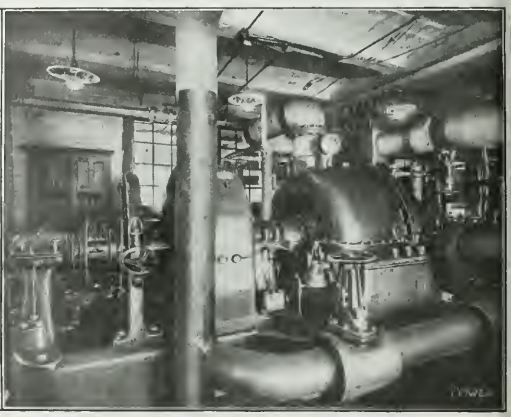


Fig. 2. Generator End of Mixed-Pressure Turbine

The turbine, Fig. 1, is of the Curtis horizontal-shaft, mixed-pressure type. It is directly connected to a 300-kw., direct-current, 250-volt generator, Fig. 2. This unit utilizes the exhaust steam from reciprocating engines and auxiliary apparatus that is in excess of steam required about the plant for manufacturing purposes and steam heating. This type of turbine is particularly well adapted for the industrial plant where the low-pressure steam supply is a variable one, inasmuch as it can operate entirely on low-pressure steam or with a partial supply of low-pressure and high-pressure steam, or entirely on high-pressure steam, developing its full rated capacity under either condition with good economies.

Low-pressure steam is supplied at approximately 7 lb. gage pressure, and is controlled by a butterfly valve in the low-pressure line. The mixed-pressure feature consists of a separate set of high-pressure admission valves, which control the admission of high-pressure steam through a separate set of nozzles which are correctly proportioned to handle the steam at 130 lb. gage pressure. By this scheme of utilizing the high-pressure steam considerable better economy is obtained than by the use of a reducing valve. The admission of steam to either the low- or high-pressure element of the turbine is controlled by one governor, thereby obtaining close speed regulation for any condition of load or a variable supply of low-pressure steam.

The unit as a whole is very compact. The oiling system is entirely automatic, and a few drops of oil are applied once or twice a day to the transmission bearing of the governor.

The original power equipment of this plant consisted of four 300-kw. and one 150-kw. generators, which are direct connected to simple noncondensing engines. These engines, and all auxiliary machinery, including boiler-feed pumps and large salt-water circulating pumps, which are used for vacuum pans, exhaust into a common steam header against a back pressure which averages between 8 and 10 lb.

Steam from this header is drawn off and distributed throughout the plant, where it is used in the vacuum pans for boiling sugar, evaporators, heating water and building heating, the surplus steam above plant requirements being used in the turbine.

The problem of installing the turbo-generator was a simple one, and as the floor space required is small as compared to units of the same capacity in the plant, the turbine and generator were placed in one corner of the engine room.

Neither the original exhaust-steam piping nor headers required any marked change to make the low-pressure steam connections to the turbine. The connection between the steam header and low-pressure inlet to the turbine consists of a lagged pipe line approximately 75 ft. long. Between the common exhaust-steam header and the low-pressure line to the turbine a regulating valve is in-

alled, which maintains a constant pressure at the turne of approximately 7 lb. gage. There is installed in e low-pressure line, just ahead of the butterfly valve, hich controls the admission of low-pressure steam, a ochrane steam separator of sufficient capacity to supply ry steam to the turbine.

The top of the turbine foundation is at the level of the ngine-room gallery floor. This level was used to gain ie necessary head room for the condensing equipment ithout going to any greater depth than that of the origial basement floor. Because of the short distance to the iver, excellent results have been obtained with the conensing equipment, and during the winter season, when ie temperature of injection water is low, the vacuum has veraged very close to 29 in., measured on the mercury olumn and corrected to 30 in. barometer.

The condensing equipment is of the low-head jet type; he condenser cone, circulating pump and air pump are ll mounted on a common bedplate and driven by a steam urbine, the exhaust from this turbine being so arranged that it can be taken into the low-pressure turbine or carried to the feed-water heater.

The turbo-generator operates in multiple with the engine-type generators, and the combined capacity of the equipment is used for driving motors throughout the sugar and coffee houses, and also furnishes lighting for the office and plant buildings. The unit operates continuously 24 hours per day, six days per week, and the load averages very close to its rated capacity.

No test has been made to date to determine just what the overall economy of the plant is since the installation of the turbo-generator, but benefits that have been derived from the installation can be briefly summed up as follows: 300 kw. additional capacity is obtained from the low-pressure steam, which, in the past, had gone to waste; no additional labor or operating cost; no additions to building or boiler capacity; better operation of reciprocating engines, as a constant back pressure can be maintained, thereby allowing for closer setting of the engine valves, resulting in much smoother operation.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—In which Hunter explains something about centrifugal pumps for mine service, and we visit a mine to see one in operation. Upon emerging we come upon a vast culm pile, at one time thought of no value.

A few days after my last interview with Hunter I strolled down to the depot to watch the trains come and go. While comfortably seated on a baggage truck, my idle musings, as to where all the travelers were going, were interrupted by a terrific slap on the back, the force of which knocked a partly consumed cigar onto the coal-dust-covered platform.

Turning, I found my assailant was Hunter, who was going about 30 miles down the line, and as he extended an invitation to go with him, I gladly accepted. After getting comfortably seated in the train the conversation drifted from one topic to another, until Hunter mentioned that he was going to witness the operation of a motor-driven centrifugal pump. That was my chance.

"Can centrifugal pumps be used to advantage in mines?" I asked, "if so, why haven't we seen them in the mines we have visited?"

"Because most of the mines have been steam propositions from the start and it would mean a large financial outlay to change over to electricity. Mines having alternating-current generating machines will be found to have part, if not all, of the pump equipment of the centrifgugal type. After you have seen one of these units running you will understand that it is a comparatively simple machine, having no valves to keep in repair and will pass a large amount of water, in fact, it will deliver the same amount of water under the same conditions of head as the reciprocating pump, and use less fuel to produce the power."

"Isn't the speed at which the pump runs a factor against its use?" This question was asked because I had visions of a motor driving a pump at high velocity.

"The revolution of a pump is dependent on the head against which it operates, as is also its capacity, for a few revolutions faster or slower will considerably vary the amount of water delivered. It won't do to overspeed a pump and the best results are obtained when the velocity through the discharge is between 8 and 12 ft. per sec. If the pump is crowded beyond, the tendency is toward less efficiency."

"How much lift can be given to a centrifugal pump, and how do you get the water started in them?"

Hunter flicked the ashes from the end of his cigar and said: "It will lift water by suction as high as any pump, but there must be no air leaks in the suction pipe, as a small amount of air will affect the working of the pump and sometimes prevent the discharge of any water.

"As with any other type of pump, it should be placed as close to the sump as possible, and never more than 24 ft. above the surface of the water to be pumped; 20 ft. would be a better maximum lift.

"A mistake is sometimes made by using piping smaller than the inlet and discharge orifices, and, of course, the less elbows and bends in the pipe the better. In case the discharge pipe is long, one or two sizes of pipe larger than called for would be of advantage. Now for your second question.

"All centrifugal pumps placed above the water supply must be primed before starting. Some pumps are made with a priming device or ejector. Steam is turned on and the suction created draws the air out of the suction pipe, when water will rise in it to the pump. If the suction pipe has a foot valve, the pump can be filled with water by means of pails or by other available means. In some cases a small motor-driven pump is used for priming.

"When this type of pump is used for mine work where the head is necessarily high, a multistage unit is used, with as many stages as may be necessary to elevate the water to the surface."

"Now just hold up a little and tell me what a multistage pump is, before you go on any further," and

I handed Hunter a "Lord Somebody" to keep him sociable.

"Simply two or more single pumps combined within one casing," replied Hunter, lighting the weed. "The water is delivered from the runner of one pump to the runner of the second, and so on through the total number of stages and the pressure produced increases in proportion. Every pump should be designed for each individual case, as for any desired capacity, head and speed, to obtain the best results. The efficiency varies with the size of the unit, the average for medium-size pumps being from 60 to 65 per cent. Large pumps are rated as high as 80 per cent. efficiency.

"Like everything else this type of pump is made good, poorly and indifferently. The better-class pumps have shrouded impellers."

"Shrouded impeller, what do you mean by that?"

"Why the metal is carried up on each side of the impeller so that there will be no loss from friction of the rotating water against the inside of the pump casing. Naturally a thin film of water will exist between the outside surface of the shrouds and the inside of the pump

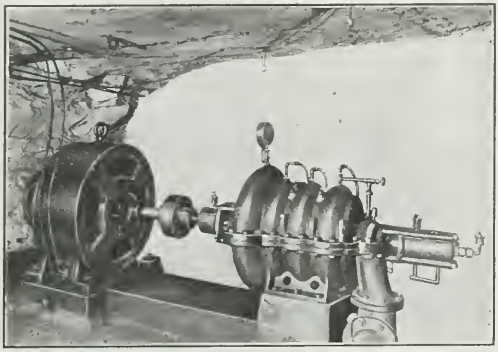


FIG. 1. MOTOR-DRIVEN, FOUR-STAGE CENTRIFUGAL PUMP. CONCRETE WALL IN THE BACKGROUND

casing. This, however, can be reduced to a minimum if the outside of the impeller and inside casing are machined."

"Then, as I understand, only such mines as are electrically equipped operate centrifugal pumps, and that is why we haven't seen more of them."

"Now don't jump at conclusions before you know where you are going to land," rejoined Hunter. "The centrifugal pump is a comparatively recent product and because other types of pump have for years been doing the work satisfactorily, there are those who do not look upon it with favor for underground use. Others, however, have looked into the merits of centrifugal pumps and back their belief by operating them. Most are motor driven for several reasons, but that is a cat of another color."

"That means," said I, "that those who do not favor centrifugal pumps are prejudiced against them."

"Yes and no, because the service of the pump depends somewhat upon the shape and size of the impeller passages and the amount and size of foreign matter, such as chips, coal and small pieces of rock which are likely to be picked up by the suction and pass through the pump.

"As I told you some time ago, pumps handling mine water must be protected from the acids by suitable linings, although a few mines are fortunate in having water that does not attack the metal of the pump."

"Well, you said that most mine pumps are wood lined; why can't the same thing be done with centrifugal pumps?"

"It would not be practicable to use wood because of mechanical and operating conditions, but all parts com-

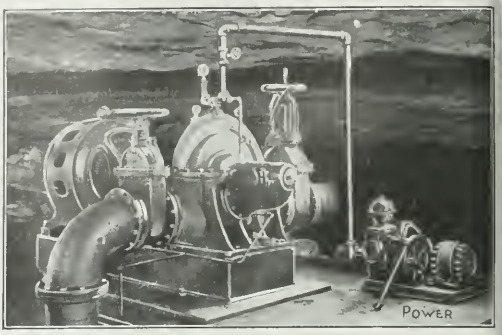


FIG. 2. CENTRIFUGAL PUMP AND PRIMING OUTFIT

ing in contact with the water can be made of bronze, which will resist the corrosive action of the water."

Just then the train slowed down at our destination, and a few minutes later we were down in the mine pump room, where I first saw a motor-driven, four-stage centrifugal mine pump. It had a capacity of 800 gal. of water per min. with a 640-ft. lift, Fig. 1. Later on in the day I saw a second, but smaller single-stage pump and priming outfit, Fig. 2. It was working against a low head and was driven by an induction motor. The priming plunger pump was driven by a small 2-hp. motor.

Coming up out of the second mine into daylight the view was one not often seen. Tons upon tons of culm

FIG. 3. WE LOOKED DOWN UPON A VAST FIELD OF CULM AND MINE REFUSE

and mine refuse partly filled the valley below the mine shaft, Fig. 3. At the far end of the culm pile a small washery was reclaiming fuel from the pile of refuse that had been thought of no value when taken from the mine. In the distance the village of miners' houses could be seen, toward which we made our way, over the mass of dirt, coal and slate. A train soon brought us back to our starting point, where we parted for the night.

The Theory of Centrifugal Pumps

By R. L. Daugherty*

SYNOPSIS—The various divisions of head entering into the operation of a centrifugal pump, and the characteristics of both turbine and volute pumps.

Centrifugal pumps are so called because centrifugal force or the variation of pressure due to rotation is an important factor in their operation. However, as will be shown later, there are other factors which enter into their operation. Centrifugal pumps are broadly divided into two classes: Turbine pumps and volute pumps.

In the turbine pump the impeller is surrounded by a diffusion ring containing diffusion vanes, whose function

Fig. 1. Casing Surrounding Diffuser

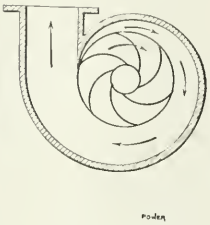


Fig. 2. Volute Casing

is to gradually reduce the velocity of the water leaving the impeller and thus efficiently transform the kinetic energy into pressure energy. The casing surrounding the diffuser may be either circular, as shown in Fig. 1, or it may be of a spiral form.

The volute pump has no diffusion vanes, but, instead, the impeller is surrounded by a casing of spiral form. (See Fig. 2.) This spiral is known as the volute, from which the pump receives its name. Some pumps may have a circular instead of a volute casing, but, as this type is less efficient, it will not be considered in the classification.

By many, the term "centrifugal pump" is understood to mean a pump without diffusion vanes, while one with diffusion vanes is called a turbine pump. The writer, however, prefers to use the term in its broader sense so as to cover both types.

Head or Lift

In all cases the head developed is the vertical height to which the water is lifted, plus the velocity head at discharge, plus all losses in the suction and discharge pipes. It is also the difference between the total head on the discharge and the suction sides of the pump. If pressure and vacuum gages are used to determine this, then the head developed equals the pressure-gage reading (in feet of water) plus the vacuum-gage reading (in feet of water), plus the difference in elevation of the centers of the gages, plus the velocity head in the discharge pipe, minus the velocity head in the suction pipe.

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Head of Impending Delivery

The head developed by the pump when no discharge occurs is called the "shutoff head" or the "head of impending delivery." We are then concerned only with "centrifugal head" or the height of a column of water sustained by centrifugal force. If a vessel containing water is rotated at a uniform rate the water will tend to rotate at the same speed and the surface will assume a curve as shown in Fig. 3. This curve approximates a parabola, and

$$h = u^2_2 / 2g$$

where u_2 = Linear velocity of the vessel at a radius, r_2.

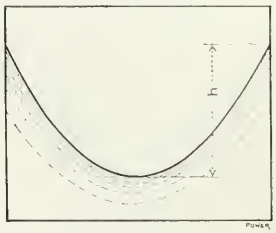


Fig. 3. Parabolic Form of Water Surface

If the water be inclosed so that its surface cannot change, the pressure will follow the same law. If, as in Fig. 4, the water is set in motion by a paddle wheel in a chamber and a pressure chamber surrounds that containing the water in motion, then the pressure in the outer chamber will be greater than that at the center by the amount $u^2_2/2\,g$.

Although ideally the head of impending delivery equals $u^2_2 / 2g$, pumps give values either above or below

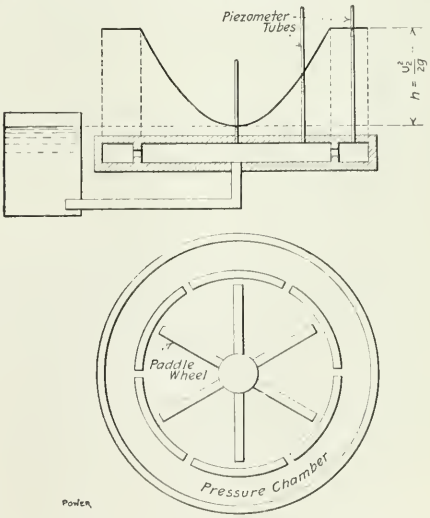


Fig. 4. Illustrating Pressure at Different Points

that amount in many cases. This may be accounted for in a number of ways. In any pump there is never a case of zero discharge; for a small amount of water, about 5 per cent. of the total rated discharge, will be short-circuited through the clearance spaces. This will tend

to make the shutoff head greater or less than $u^2_2 / 2g$, according to whether the pump has a rising or a falling characteristic. Also the more the vanes are directed backward the more tendency there is for internal eddies to be set up, which tend to reduce the head. This is one reason why different angles of vanes give different values of shutoff head, and another is that the more the vanes are directed backward the more rapidly will the pressure fall, with an increase of discharge, as will be shown later.

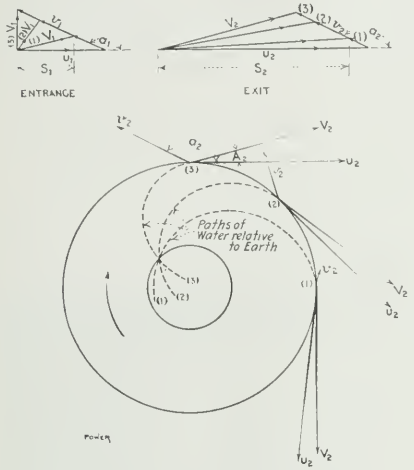


FIG. 5. RELATIVE VELOCITIES AT ENTRANCE AND EXIT

Furthermore, if the water in the eye of the impeller is not set in as rapid rotation as the impeller itself the head may be further reduced. There is also a tendency for the water surrounding the impeller to be set in rotation and this, on the other hand, tends to increase the head since the effective value of r_2 and thus u_2 is greater than the nominal value used. However, there is usually little deviation from the ideal case with most pumps and the actual head of impending delivery is such that h equals from 0.9 to 1.1 of $u^2_2 / 2g$.

HEAD DURING DELIVERY

When flow occurs the foregoing relation no longer holds, for other factors besides centrifugal force enter in. There may be an increase in head for small values of discharge, in which case the pump is said to possess a rising characteristic. On the other hand, the head may continually decrease as the discharge increases above zero, in which case the pump is said to have a falling characteristic. In the equations that will now be given the following notation will be employed:*

u = Velocity of point of impeller in feet per second;
v = Velocity of water relative to impeller in feet per second;
V = Velocity of water relative to earth in feet per second;
s = Tangential component of V in direction of rotation;
A = Angle between V and u;
a = Angle between v and u = vane angle;
A' = Angle made by diffusion vane with tangent;
F = Area of stationary passages in square feet at right angles to flow;
f = Area of impeller passages in square feet at right angles to flow;
H = Head delivered to water by impeller;
h = Head developed by pump;
h' = Head lost in pump by friction and shock;
q = Cubic feet per second;
w = Weight of a cubic foot of water = 62.5 lb.;
W = Pounds of water per second = $w\ q$.

The subscript $(_1)$ denotes entrance to the impeller, the subscript $(_2)$ exit from impeller, and subscript $(_3)$ a point in the casing. Briefly, v is called relative velocity and V is called absolute velocity. The following relations will also be noted:

$$H = h + h' \text{ and } s = V \cos A = u + v \cos a$$

Diagrams showing relations of these velocities at entrance and exit for several values of discharge are shown in Fig. 5. For a very small discharge the water takes path (1) for an intermediate discharge path (2), and for the normal discharge for which the pump is designed path (3).

Since the area of the impeller exit, f_2, is constant, the discharge is proportional to v_2 for

$$q = f_2\ v_2$$

Although the velocity V_2 decreases as v_2 increases, the area of the stream increases as the angle A_2 increases at such a rate that the product of V_2 and the corresponding area is an increasing quantity.

When there is no discharge the water in the eye of the wheel is in rotation; as the discharge increases experiment shows that this rotation decreases until at normal operation it is nearly zero. Thus there appears to be no sudden deflection of the water at entrance for any value of the discharge. The slight shock loss at entrance and the friction in flow through the impeller passages will be taken as proportional to the square of the velocity of flow, in accordance with the usual custom in hydraulics, and will be represented by $k\ v^2_2 / 2g$, where k is a coefficient determined by experiment.

With the turbine pump there will be a shock loss at discharge for all values of discharge except one, for with only one value of the discharge will the angle $A_2 =$

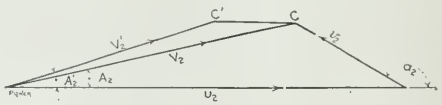


FIG. 6

A'_2. If the water leaves the impeller with velocity V_2 directed at angle A_2, it will be forced by the diffusion vanes to take the direction A'_2 and another velocity V'_2 (see Fig. 6). It will be assumed that the loss due to this sudden change is $(CC')^2 / 2g$. It can be shown that

$$(CC') = u_2 - k'\ v_2$$

where

$$k' = \frac{\sin (a_2 - A'_2)}{\sin A'_2}*$$

The total loss of head for the turbine pump may now be expressed as

$$h' = k \frac{v^2_2}{2g} + \frac{(u_2 - k' v_2)^2}{2g} \quad \text{(see curves Fig. 7)}$$

*See "Textbook on Hydraulics," by L. M. Hoskins.

With the volute pump water leaves the impeller with a velocity V_2 and enters a body of water in the casing, moving with a lower velocity V_3. In accordance with the usual method the loss due to the sudden reduction of velocity may be assumed as

$$(V_2 - V_3)^2 / 2g$$

For a very small discharge V_2 will be large, being nearly equal to u_2 and V_3 will be small. Thus the loss will be large. But as the discharge increases, V_2 will decrease while V_3 increases and thus the loss decreases. There will also be a slight change of direction, although not abrupt. The water in the case flows nearly parallel to a tangent to the impeller; the greater the discharge the greater the angle A_2 becomes, so that any loss due to a change of direction might here be included with the friction loss in the impeller passages. If V_2 be expressed in terms of u_2 and v_2, and V_3 in terms of v_2 and the ratio of areas of impeller passage and volute passage, the total loss of head for a volute pump will be

$$h' = k\frac{v^2_2}{2g} + \frac{\left(\sqrt{u^2_2 + 2\cos a_2 u_2 v_2 + v^2_2} - (f_2 f F_3)\, v_2\right)^2}{2g}$$

Thus the losses approximately follow the same law in the two cases. In the turbine pump there is a gradual reduction of velocity but, except for one discharge, a sudden change in direction. With the volute pump there is no abrupt change in direction but a sudden change in velocity. The transformation of kinetic energy into pressure energy is incomplete in either case, but it is believed that it is more nearly complete in the turbine pump than in the volute pump. In spite of the extra hydraulic friction produced by the diffusion vanes it is to be expected that the efficiency of the turbine pump will be a trifle higher than that of a good volute pump. To secure a higher efficiency, other things being equal, we have merely to assume a slightly lower value of k.

The head input to the water from the impeller is given by either of the two following formulas: By the first method

$$\textit{Centrifugal head} = \frac{u^2_2}{2g} - \frac{u^2_1}{2g}$$

Then considering the conditions of flow through the impeller passage, by Bernoulli's theorem:

$$\frac{p_1}{w} + \frac{v^2_1}{2g} = \frac{p_2}{w} + \frac{v^2_2}{2g}$$

or the change in pressure due to change of relative velocity is

$$\frac{p_2 - p_1}{w} = \frac{v^2_1 - v^2_2}{2g}$$

Also the change of energy due to difference of kinetic energy of the water is

$$\frac{V^2_2 - V^2_1}{2g}$$

The total head delivered to the water by the impeller is the sum of these three items or

$$H = \frac{u^2_2 - u^2_1}{2g} + \frac{v^2_1 - v^2_2}{2g} + \frac{V^2_2 - V^2_1}{2g}$$

The second method is not so obvious nor so easily derived, but is more readily used. It is based upon the principle of angular momentum. (See Hoskins' "Hydraulics.") The resulting equation is

$$H = \frac{1}{g}(u_2 s_2 - u_1 s_1)$$

Either equation will give the same results.

With no discharge the water in the eye of the wheel will be in rotation so that the effective r_1 is zero and thus $u_1 = 0$. As the discharge increases this rotation decreases and when the discharge is that for which the pump was designed, then, ideally, there is no rotation in the eye of the wheel and the entrance velocity is radial, as shown in Fig. 5 (3). Thus for the normal delivery

$$s_1 = V_1 \cos 90 = 0$$

For these two cases the second term in the above expression becomes zero. For values of discharge between these two, the effective value of r_1 and thus u_1 is probably very small, due to the rotation of water in the eye of the wheel for small discharges and, although this rotation be-

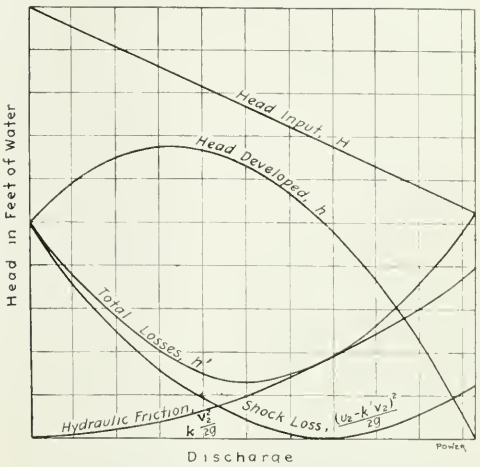


Fig. 7. Variation of Head with Discharge

comes less for greater discharges, s_1 approaches zero for larger discharges. It involves little error to omit the second term altogether; then

$$H = \frac{1}{g}(u_2 s_2) = \frac{u_2}{g}(u_2 + v_2 \cos a_2)$$

In the case of no discharge it has been shown that $u_1 = 0$, and it is also seen that $V_2 = u_2$ and $V_1 = 0$. Thus by either of the preceding formulas

$$H = 2\frac{u^2_2}{2g}$$

But, as has been seen, the ideal head at no delivery is $\frac{u^2_2}{2g}$

However, referring to the expressions for loss of head in either the turbine or the volute pump we find that for $v_2 = 0$ that

$$h' = \frac{u^2_2}{2g}$$

The loss should be expected to approach this value, for, imagining a very small flow, the water will leave the impeller with a velocity nearly equal to u_2, while in the case it enters a body of water practically at rest, so that its kinetic energy is wholly lost. Thus for zero discharge

$$h = H - h' = 2\frac{u^2_2}{2g} - \frac{u^2_2}{2g} = \frac{u^2_2}{2g}$$

as was shown in the first place from a consideration of centrifugal force alone.

The ideal characteristic curves of a turbine pump are shown in Fig. 8. If a_2 is less than 90 deg., H increases as r_2 increases. If a_2 equals 90 deg., H is constant for all values of r_2. If a_2 is greater than 90 deg., H decreases as r_2 increases. The larger the angle a_2 is made the more rapidly will H decrease. The losses, h', subtracted from H give the net head developed, h. The hydraulic efficiency is equal to h/H. The gross efficiency equals the hydraulic efficiency times the mechanical efficiency, or it is usually the relation: water horsepower divided by brake horsepower.

Actual Head During Delivery

Actual tests show that this theory, while giving the general nature of the characteristics, does not give absolute values correctly. Thus a test would show that the actual head developed by the pump was less than is shown by Fig. 8. But it would also be found that the efficiency would not be correspondingly reduced. Since $H = h/e$, it is seen that actually H must be a curve of the general form shown in Fig. 9. Several reasons account for this discrepancy. The theory idealizes the conditions by assuming that all particles of water leave the wheel with a velocity, v_2, directed at angle a_2. Actually, the velocity of different particles will vary considerably from this average, and there is no assurance, moreover, that the average direction of all of them will be the same as the vane angle, a_2. Also, it has been assumed that the water flows through the entire impeller passage, but there is strong evidence to show that there is a "dead water" space on the rear of each vane. Some designers also maintain that, at normal discharge, the effective value of r_2 is not the value of the impeller radius but only the distance to the center of the impeller passage section taken normal to the vane at point of exit.

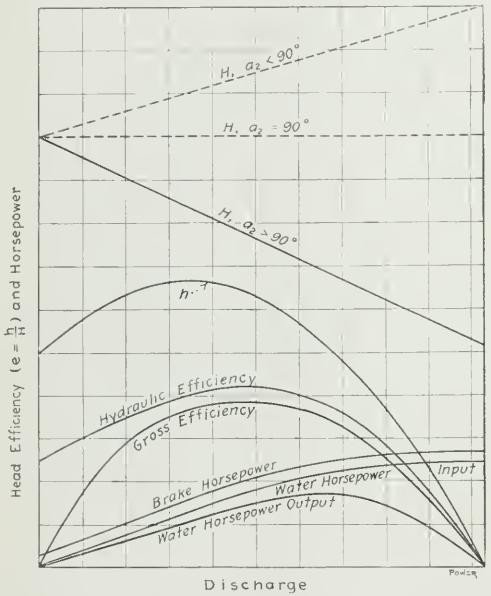


Fig. 8. Ideal Characteristics of Turbine Pump

The more vanes the impeller has, the more perfectly is the water guided and the more nearly do the actual characteristics approach the ideal. It is necessary to use sufficient vanes to guide the water fairly well, but it is undesirable to use too many because of excessive hydraulic friction. Within reasonable limits, however, the efficiency is but little affected. If the real H is lowered by fewer vanes, h is lowered at about the same rate, and the ratio is about the same.

By different values of a_2 and different numbers of vanes it is possible to produce a pump with steep, flat or rising characteristics. A steep characteristic is one where the pressure falls off rapidly as the discharge increases above zero. With a rising characteristic the pressure increases slightly for small values of discharge. A flat characteristic is intermediate between the two.

The value of the head developed by a pump when operating at its best efficiency depends quite largely upon the design of the pump. Very roughly, the most efficient head during delivery may be taken as,

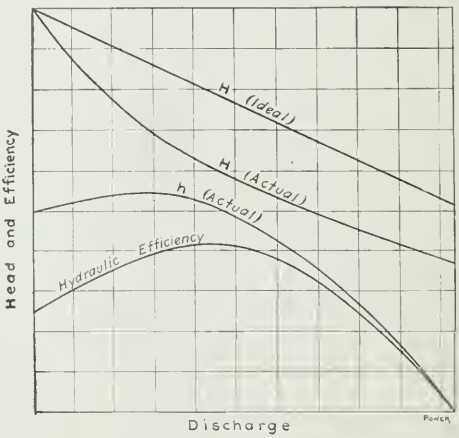


Fig. 9. Actual Head during Delivery

$$h = 0.6 \text{ to } 0.8\frac{u^2_2}{2g}$$

Thus the best lift of a given pump will vary as the square of the pump speed. Also the best value of the discharge, which is, of course, obtained with this best lift, will vary directly as the pump speed. Thus the horsepower will vary as the cube of the speed.

In Fig. 10 is shown a series of curves for different speeds. If it is desired to see what the discharge will be for different speeds at a constant head it is merely necessary to follow along a horizontal line for the given head. For a constant discharge follow the vertical line, and for maximum efficiency follow the curved line.

General Observations

The difference between water horsepower output and water horsepower input equals the hydraulic losses. As the speed is increased these losses will increase, but, as

the water horsepower increases at the same rate, it is probable that the maximum hydraulic efficiency will be nearly constant. The difference between water horsepower input and brake horsepower equals the drag of the impeller (disk friction) and the friction of the bearings. For very low speeds these losses do not increase as fast as the water horsepower with an increase in speed; hence the maximum gross efficiency will be greater as the speed and consequently the head increases. But when the higher speeds are reached the disk friction begins to increase faster than the water horsepower and the maximum gross efficiency begins to decline. Thus the head that may be efficiently developed by a single impeller is limited.

The speed and head are thus seen to exert some small influence upon the efficiency of a single pump. Assume,

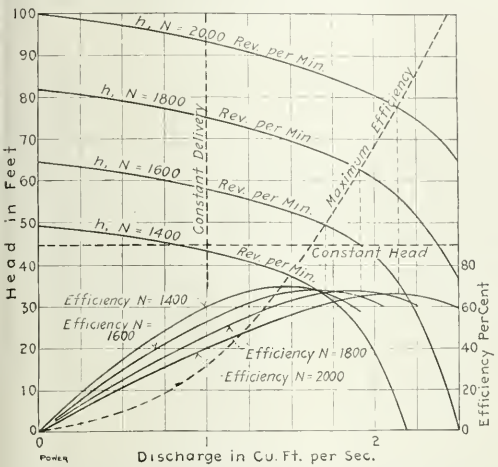


FIG. 10. DISCHARGE FOR DIFFERENT SPEEDS

however, a series of pumps of the same diameter of impeller and running at the same speed. They will all develop the same head, provided the vane angles are the same. But suppose that they are made with the impellers of different widths; the discharge areas will then be proportional to the widths and the quantity of discharge will vary in the same ratio. The friction of water in flowing through a large passage is less than that of a smaller quantity of water flowing with the same velocity in a

RELATION BETWEEN CAPACITY AND EFFICIENCY

Capacity, gallons per minute	Gross Efficiency, per cent.
75	55
200	65
900	70
5,000	75
10,000	80

smaller passage. Therefore, the hydraulic efficiency of the pump with a larger capacity would be somewhat greater than that of a smaller capacity. But the water horsepower of this series of pumps varies directly as the discharge while the disk friction and bearing friction would be practically constant for all. The result of these two causes is to make the efficiency largely a function of the capacity. A general idea of the relation between capacity and efficiency is shown by the accompanying table.

Test of a Two-Stage Turbine Pump

BY A. A. POTTER AND W. W. CARLSON

The following test may prove of value to those interested in pumping water for irrigation or other purposes by means of turbine pumps and oil engines.

The irrigation plant in question was located in western Kansas at an elevation of about 2850 ft. Water was found at a depth of 65 ft., but in order to eliminate some of the difficulties encountered, the pump was set at a depth of 123 ft., as shown in the sketch. Power was supplied by a 16x24, single-cylinder, four-stroke-cycle oil engine using 42-deg. Baumé oil. The pump was run at nearly 800 r.p.m. during the test, and the water was measured by means of a trapezoidal weir, all measurements being checked with a pitot tube.

The data of the test are given in the table and it is evident that for every gallon of fuel used, 5400 gal. of water was pumped. Figuring the cost of oil at 3c. per gal. gives 1800 gal. for 1c., and, as shown, 617.5 gal. of water was pumped per minute, at an expense of about ⅓c. An acre-foot would be pumped in 70½ min. at a cost of 24½c. At this rate about 10 acre-feet could be pumped in 12 hr. These figures are for fuel oil alone, and do not include any of the other charges.

TEST DATA AND RESULTS

Duration of test, minutes	60
Speed of engine, r.p.m.	184
Speed of pump, r.p.m.	798
Mean effective pressure of engine	60.0
Indicated horsepower of engine	67.6
Pump suction head, actual inches of mercury	6.46
Barometer	27.61
Pump suction head reduced to 30-in. barometer, feet	8.12
Pump discharge head, feet	127.06
Total head, feet	135.18
Head on weir, inches	4.1
Water pumped per minute, gallons	617.5
Fuel used per hour, pounds	46.5
Fuel used per minute, gallons	0.1141
Water pumped per gallon of fuel, gallons	5,400
Work done by pump per minute, foot pounds	695,000
Pump horsepower	21.10
*Engine horsepower	52.90
Mechanical efficiency of pump per cent	39.90
Heat value of fuel per pound, B.t.u., high	17,240
Heat value of fuel per pound, B.t.u., low	16,322
Heat value of fuel per gallon, B.t.u.	117,100
Duty of pump per 1,000,000 B.t.u., foot-pounds	51,900,000

* This is based on a mechanical efficiency of the engine of 85% and belt losses of 8%.

The duty of the pump was obtained by multiplying the foot-pounds of work done per minute by 1,000,000 and dividing the product by the B.t.u. in the fuel used per minute, or

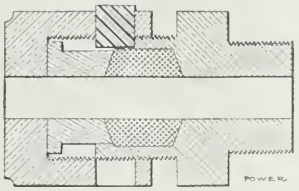
$$Duty = \frac{695{,}000 \times 1{,}000{,}000}{0.1141 \times 117{,}100} = 51{,}900{,}000\ ft.\text{-}lb.$$

The Pacific Gas & Electric Co., Calif., has applied to the Railroad Commission for a certificate of public convenience and necessity for the construction of three additional power plants on the extension of Bear River, Placer County, and the construction of a transmission line from the Bear River development to Nicolaus, in the Sacramento Valley. The applicant stated that the construction would provide for 35,000 hp. at a cost of $2,396,000. A supplemental decision was rendered by the Commission on May 14 providing that the Northern California Power Co. should make returns to its patrons of all money previously collected in excess of the established rates.

In the movement for better efficiency, many men and firms are placing themselves before the public as specialists in efficiency, and those who wish to take up engineering work, are in doubt as to who may or may not be satisfactory. As an aid to those seeking work in efficiency organization, and those who desire to employ men for such work, the secretary's office of the Efficiency Society, 29 West Thirty-ninth St., New York, has become a clearing house where advice may be secured which will be impartial and authoritative.

Lawrence Improved Stuffing-Box

This stuffing-box is designed to slip on over the piston rod or valve stem and screw into place. It is then packed with any suitable packing. The gland is held against the



Stuffing-Box

packing by a follower which screws up on the external threaded portion of the base. The gland of the stuffing-box, which is manufactured by the Lawrence Manufacturing Co., Key West, Fla., is thus forced against the packing without being turned.

A locking device, consisting of a lug which extends through an opening in the follower, fits in one of the grooves in the base. This locks the follower and prevents it from working loose. The locking lug is held in place by either a spring or screw.

Haulage-Engine Repairs

By T. D. Parfitt

Some time ago a serious accident occurred to a main haulage engine used on an endless-rope haulage system. One of the foundation bolts that held down the base plate under the pedestal of the main drum broke off close under the nut, permitting that end of the bearing to lift. At the same time one of the arms of the main drum cracked close to the rim.

A strong chain and turnbuckle were rigged, as shown in Fig. 1, a small nick was cut in the arms of the drum to hold it in place and then the turnbuckle tightened. A hole was also drilled in the crack and tapped for a ⅞-in. bolt, which was screwed in place to prevent the crack from extending through the arm.

While one gang was working on this job, another worked in the foundation, cutting a round hole in the base plate, until nearly half of a nut hold was had on the foundation bolt, then a clamp was placed over the engine-foundation bolt, to which two turnbuckles were attached. The other end of each eye-bolt was made with a large eye on one end through which a 2-in. rod was run and placed behind the bolts, holding the pedestal to the base plate. This will finish the day's work without loss of tonnage.

We then went to work and drilled two 2-in. holes in the concrete foundation about 3 ft. deep. A bolt made with grooves cut around it was inserted in each hole, which were then filled in with babbitt metal. Then two clamps were made and placed, as shown in Fig. 2, reaching from the base of the engine to the base plate of the drum pedestal. They were then drawn tight. The engine has been in constant use for nearly a year since the repair and has not given any trouble, and at present it looks as though it would run indefinitely.

New Method of Boiler Cleaning

A new method of boiler-scale removal has been recently invented and placed upon the market in England by Adolph Schror, says *Coal Age*. This method is radically different from those common in this country, which are strictly mechanical in their action.

The principle of the new apparatus is simple. It consists in the employment of an oxyacetylene flame of high temperature, but of moderate pressure, which is rapidly played upon the scale. The effect is to disintegrate and break down the deposits, and, notwithstanding the high temperature of the flame, the makers claim that there is no cause for anxiety on the score of undue heating of the boiler tubes, and that the apparatus may be used to remove the thinnest scale.

Contracts under this system are undertaken on the "no cure, no pay" principle, by the Pyro Boiler Cleaning Co., of London, and it is understood that thus far the results obtained have been entirely satisfactory.

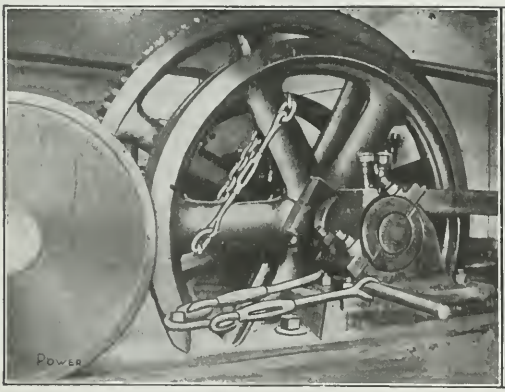


Fig. 1. Temporary Repair

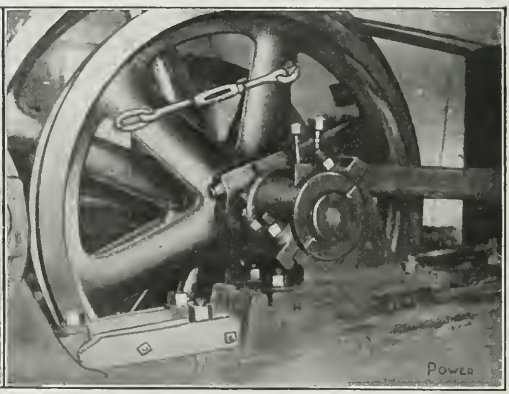


Fig. 2. Permanent Repair

Half a million dollars is to be spent for a power plant project to supply electric light and power to Las Vegas, Nev., and adjoining valleys. The water for developing the power is to come from the Charlestown mountain range above Indian Springs, its source being 11 small springs.

Development in V-Notch Recording Meter

By Joseph Esherick

SYNOPSIS—The advantages of this form of V-notch type of meter are brought out, which consists of the long storage chamber, new type of clock-driven integrator, and simple method for testing when the meter is in operation.

There are various methods for measuring water and other liquids, such as by the pitot tube, venturi meter and the V-notch weir, all of which have found favor with the users. The advantages claimed for the latter method are increased accuracy at high and low rates of flow, depending as it does upon the law of gravity, water falling over a 90-deg. V-notch, the amount of which is a

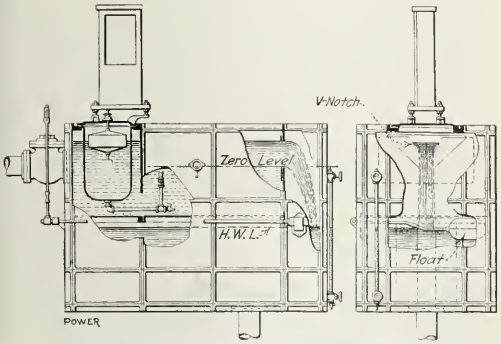


Fig. 1. Extra Storage Type of Meter

known quantity (Thompson's formula). Further, its accuracy is unaffected by temperature or velocity changes, and the flow may be checked at any time.

Increased Storage Space above and below Weir Chamber

The V-notch weir type of meter is independent of temperature and velocity changes, because the design permits of a storage space where water or liquid being measured can accumulate before passing over the weir. Although the flow into the tank of the recorder may fluctuate, its irregularities are absorbed by this stored volume, resulting in a perfectly steady flow over the weir.

In the accompanying drawing, Fig. 1 illustrates a new patented extra storage type V-notch recording meter. The advantage of this type of tank is found in the long still-water chamber above the weir, and an even longer storage chamber below the weir. It is found in practice that the longer these surfaces can be made, the steadier the chart record, and hence the more accurately will the meter record fluctuating rates of flow.

The lower storage surface below the weir controls the opening and closing of the inlet valve, and the advantage of increased storage at this point is, that the larger this surface, the smaller will be the vertical change for a given change of volume flowing over the weir, affording a smoother chart and one more easily planimetered.

Tests of this type of meter operating the inlet valve from the short water surface below the weir, and then with the same load conditions lowering the surface until it extends the length of the tank, as shown, result in widely different curves. The curve recorded when the control valve is operating on the long storage surface is very much smoother than when the valve is operating on the short storage surface.

Another advantage of this new design is found in the ease with which the shape of the tank lends itself to peculiar installations. Some cases require a very much larger storage space than others. In these cases it is easy to increase the depth of this storage space, by making the tank deeper the desired amount, at the same time keeping the same length of tank. This design seems to give maximum storage space for minimum floor space.

For plants where the head room is limited there is a low-head type of recorder, Fig. 2. The tank is longer than in the new type, but the distance from the zero line to the storage-water level below the weir is less.

New Type Clock-Driven Integrator

In the past the V-notch type of recorder has been equipped with a clock mechanism for driving the recorder chart, and a constant-speed motor for driving an integrator. Under extreme conditions where the instrument was subjected to severe heat, the clock mechanism has maintained perfect accuracy, but the motor has not proved quite so satisfactory. The heat sometimes so affects the lubrication of the motor that frequent oiling is required.

Although this was not so much a mechanical difficulty as lack of attention from the operator, it has, nevertheless, seemed wise to avoid it.

Guided evidently by the success of the clock mechanism driving the chart drum, the manufacturer has developed

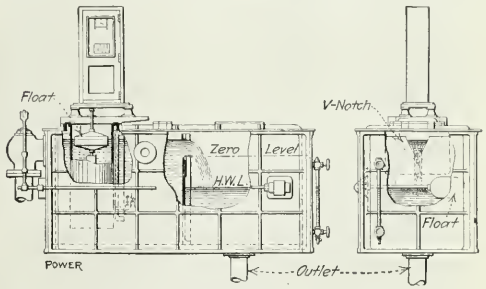


Fig. 2. Low-Head Type of Meter

the clock-driven type of integrator shown in Fig. 3. It consists of a clock-driven aluminum disk which revolves about four times an hour. Across the radius of this disk a friction wheel moves, which is attached to and drives a counter mechanism, and as this wheel moves farther and farther from the center of the aluminum plate the counter adds up more and more. The counter itself is supported on a frame attached to the horizontal slider bar, which in turn is moved laterally by the pointer arm, which engages the cam surface. The pen arm is also attached to this same slider arm. This arrangement makes it possible for the operator to obtain a reading on

either the counter dials or on the chart, because each system is driven by separate clock mechanism.

Method for Testing While in Operation

A disadvantage to all types of recorders and meters has been the impossibility of testing them without trouble and expense. The most positive method has been the erection of an elaborate outfit of tanks on scales for testing by weight.

In Fig. 4 is illustrated what is known as the "hook gage" by which the V-notch type of meter seems to lend itself to a test of great simplicity, as it can be tested at the normal rate of flow, whether fluctuating or not, and at the highest rate, corresponding with the peak load of the plant.

The "hook gage" is illustrated at the right of the tank. It consists of a glass water gage containing a hooked vertical rod inside. It has been attached to the V-notch tank in the middle weir section, and the hook is set on the water line, which is the height of the water falling over the V-notch.

The hook is adjustable up and down, and has a scale with a vernier attached, so that the height can be read to hundredths of an inch.

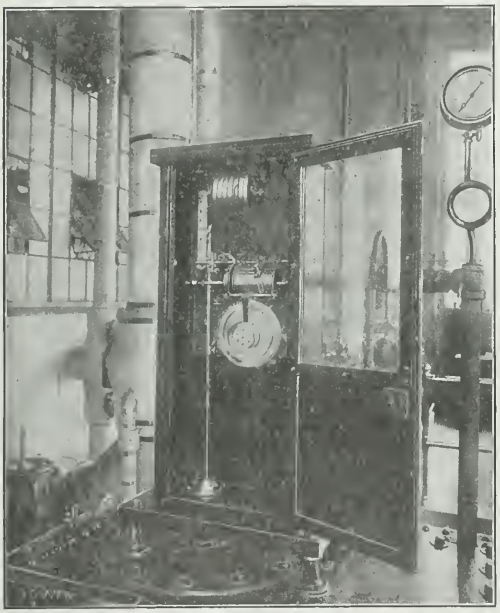


Fig. 3. Clock-Driven Type of Integrator

In testing a V-notch meter this hook gage is used in taking readings every three minutes for two or three hours, and these values of the head of water flowing over the V-notch are substituted in Thompson's formula for the flow, and a value obtained of the quantity which has passed over the V-notch in this time. This quantity is now compared with the quantity which the recorder shows by planimetering the chart in the same time.

For users who prefer not to purchase a gage for testing purposes, the manufacturer furnishes one at a nominal rental.

Accurate measurement of water and other liquids is a subject rapidly growing in importance, and remarkable advance has been accomplished in the last few years.

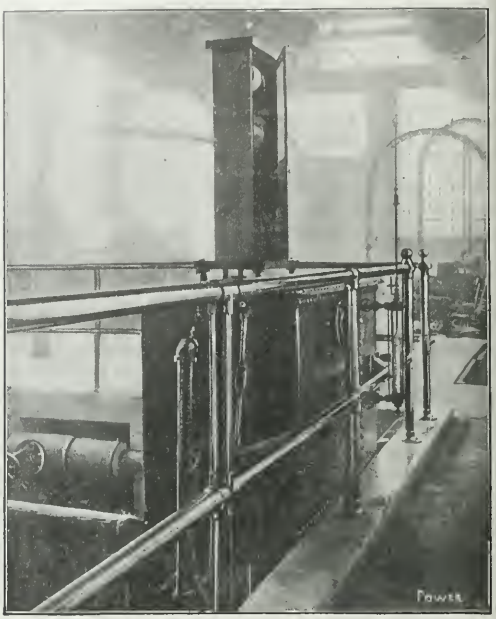


Fig. 4. Meter and Hook Gage

Probably the largest application of water-metering appliances has been in steam plants for the measuring of boiler feed, although its possibilities are almost unlimited, and hundreds are in use for a wide variety of other purposes.

Chimney Damaged by Lightning

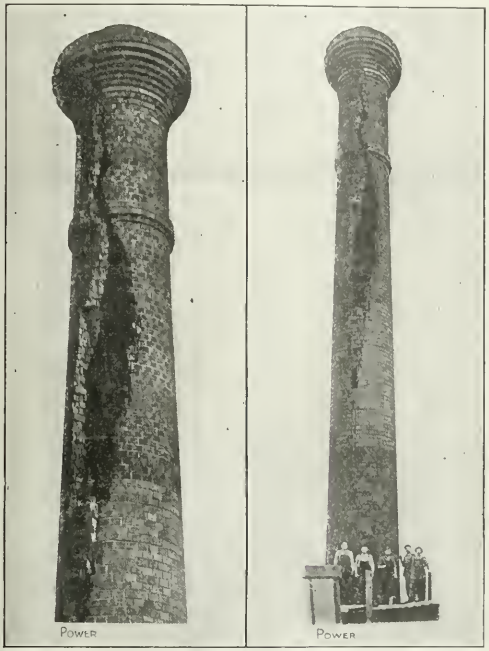
By A. D. Williams

The 5x135-ft. beautiful tapestry-brick chimney serving the heating plant of the two factory buildings of M. T. Silver & Co., and the Sunshine Cloak & Suit Co., Cleveland, Ohio, was struck by lightning during a heavy thunder storm that passed over the city on the night of June 19. The storm came from the northwest and the lightning struck the north side of the chimney just below the brick astragal, cutting a gash about 3 ft. wide at the widest point and opening a crack in the shaft that extends from the second course of brick in the astragal down to a point just below where the men are standing, a distance of about 60 ft. The major portion of the wreckage fell through the roof of the Silver & Co. factory within a few feet of the stack, but some pieces of brickwork were thrown from 20 to 30 ft., breaking skylights, while a small part was thrown out into the street in front of the building, a distance of about 70 ft. A loose piece of brickwork hangs in the gash just above the small hole in the shaft. A scaffold was erected around the chimney

so that the upper 60 ft. can be torn down. The damage is estimated at $5000.

One of the interesting features of this wreck is that the radial brick of which the chimney is built were cut through and the mortar seams were not followed. In some places brick were cut within an inch of the end and still adhered tightly to the mortar. The mortar dowel was shown at nearly every horizontal seam. Pieces comprising parts of several brick with the mortar between them held together after their tumble. The chimney was built by the Alphons Custodis Chimney Construction Co.

[This accident serves to show what a radial, tongue-and grooved-brick chimney will withstand without crumbling. Had the chimney been of ordinary solid brick it would undoubtedly have fallen when it was hit.—EDITOR.]



HOW LIGHTNING GASHED THE CHIMNEY

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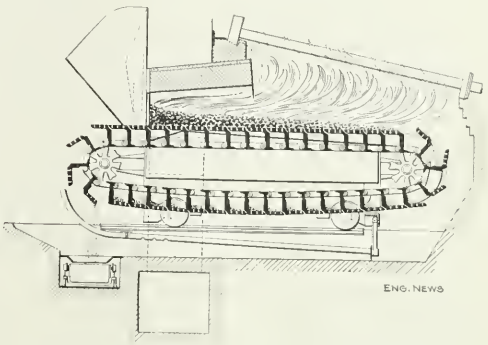
It is estimated that investment in the central-station industry is capitalized today at about $2,500,000,000, and that the earnings are apparently around $350,000,000. Quoting from the report of the Committee on Progress before the 1912 convention of the National Electric Light Association, "There can be no great exactness to these estimates, as the general census of the central stations will not be taken until next year, and the last United States report is that of 1907." It is apparently estimated by those who ought to know that the central station income is somewhere around $400,000,000. The "Electrical World" gave the following data on the electrical industry:

Value of electrical apparatus made	$350,000,000
Electric railway earnings	635,000,000
Central-station earnings	450,000,000
Telephone earnings	350,000,000
Telegraph earnings	85,000,000
Isolated-plant service	125,000,000
Miscellaneous electric service	125,000,000

Making a grand total of approximately $2,120,000,000.

Chain-Grate Stoker Which Returns Its Ashes

At the new power station of the combined municipal system of Burslem, Fenton, Hanley, Longton, Stoke and Tunstall, in the Staffordshire pottery area of England, water-tube boilers have been equipped with a chain grate of new type, recently developed. This is shown in sectional elevation in the accompanying figure from London *Electrician*, Apr. 11, 1913. The device consists essentially of an endless chain of L-shape grate bars mounted (inverted) on chains, the links of which run over sprocket wheels driven from a countershaft. The tops of the grate bars are perforated and slotted for the passage of air through the fuel. This air supply enters from two rectangular conduits, one at each side of the stoker near the front end, opening into side-wall recesses of graduated height. This allows automatic variation of the quantity of air to the different parts of the fire; the back receiving the smallest quantity where the fire is thinnest. Conduits also supply air to the front and back of the furnace through suitable control dampers. For the three boilers in this plant (each with a steaming capacity of 18,900 lb. per hr.) two fans are employed, each delivering 118 cu.ft. of air per minute.



A CHAIN-GRATE STOKER AND ASH CONVEYOR

As shown in the accompanying figure, the shape of the bars is such that when the chain passes over the rear sprocket the ashes left on top of one bar drop to the inside angle of the next forward bar, to be carried along and dumped out of that place when the bars are again separated at the front sprocket. In this way continuous removal of ashes is secured. These grates were made by the Underfeed Stoker Co., Coventry House, South Place, London, E. C., England.

⁂

A large hoist has been erected in the shop of the Nordberg Manufacturing Co. and will soon be shipped to the Inverness Ry. & Coal Co., of Inverness, Cape Breton Island. This hoist, which is claimed to be the largest of its kind in the world, has two 34x34x72-in. cylinders and two 10-ft. drums, clutched to the shaft. Each drum, according to the "Engineering and Mining Journal," is capable of handling 10,000 ft. of 1½-in. rope. The load consists of 12 cars weighing altogether 40,680 lb. loaded. The rope weighs 35,500 lb. The hoist will be used in an inclined shaft dipping 16 deg. at the surface and 35 deg. at the bottom. The present depth is about 6000 ft. The starting stress on the rope will probably be about 41,000 lb.

ELECTRICAL DEPARTMENT

Installation and Care of Storage Batteries—I

By H. M. Nichols

Nearly every electric-generating plant, from the modest installation used for lighting summer residences to the large central stations, has its equipment of storage batteries. Sometimes the batteries are intended to help carry the peak load; sometimes their function is to furnish power during certain periods of the day when the demand for current is light; or they may be the chief dependence for current as in the case of private lighting plants, where the dynamo is run a few hours each day to charge the battery, which is then called upon to furnish all the current used during the evening. But no matter under which one of these heads the battery falls, it is frequently placed in some dark inaccessible and ill-ventilated corner, and the care it receives is of the most perfunctory kind.

It is not surprising under these conditions that the battery soon begins to give trouble, and plays out in a few years, entailing a heavy expense for the replacement of plates, etc. On the other hand, if the battery is properly installed and is given the proper care the depreciation can be rendered very small.

The present discussion will first consider the layout and installation of storage batteries, then the operation and maintenance will be taken up.

The battery room should always be separated from the rest of the plant as the acid fumes are very destructive to the generating machinery, their action on the insulation of generators and wiring being particularly destructive. The fumes also corrode the switchboard connections, cable sheaths and any other exposed parts. Moreover, the fumes if breathed are poisonous and are likely to cause a very disagreeable cough. The battery room should be located as near the main switchboard as possible, thereby reducing the cost of the connecting conductors.

The walls and floor of the room should preferably be of brick or tile. If wood is used it must be protected with several coats of acid-resisting paint. Also protect all exposed metalwork in a similar manner. The floor should pitch toward a central point, having a drain connected with the sewer through a lead trap.

The room should be well lighted and ventilated and the window panes must be either ground glass or painted glass in order to keep the direct rays of the sun from striking the battery. If the sun's rays fall directly on the battery, it will cause loss of charge by local action, and also cause the electrolyte to evaporate quickly.

In the case of large installations where lead-lined tanks are used in place of glass jars, the sun's rays are not so objectionable, provided they are not directed into the top of the tanks.

In large installations exhaust fans are often provided for carrying off the acid fumes. The battery room should be so designed that the battery will not be exposed to either extreme heat or cold, and consequently it will be necessary to provide some means for heating in cold weather.

In small installations where it is not possible to have a separate room for the battery it should be housed on shelves placed against one of the walls of the generating room. These shelves should be entirely encased with close-fitting matched boards so as to form an air-tight closet. The front should be provided with large tight-fitting doors, which when opened expose the entire battery. The acid fumes are carried off to the outside through a wooden or fiber conduit. The entire inner surface of the battery closet and all exposed ironwork should be given several coats of asphaltum or other acid-proof paint. In cold localities the ventilating duct must be provided with a wooden damper which can be kept closed in cold weather except when the battery is being charged.

Setting Up and Connecting the Cells

The cells are sometimes supported by shelving along the walls, or more often by benches that rest on the floor. The shelving and benches should be shellacked and then coated with paraffin to protect them from the unavoidable acid drip and spray. Or they may be covered with asphaltum or other acid-resisting paint. In the case of large installations the tanks are sometimes set directly on the floor. In any instance the cells must be easily accessible for inspection and the replacement of plates. There should be sufficient headroom to take out the plates without removing the cells.

Care must be taken to insulate the cells from the ground as a frequent cause of trouble is due to leakage of the current over the surface of the cells and the supports to the ground. The acid fumes keep the surfaces of the cells and supports sufficiently moist to render them good conductors. Because of this danger from current leakage it is necessary to set the cells on glass or porcelain insulators. The best plan is to stand each individual cell on four insulators of the common petticoat type, since the method will prevent current leakage between the individual cells as well as between the cells and the ground.

Sometimes a double system of insulators is used. In small installations, however, where it is not desired to go to the expense of supporting each cell separately the benches on which the cells set can be insulated from the ground instead. Lead-lined tanks are usually set directly on the insulators but sometimes glass cells are set on wooden trays that rest on the insulators. The trays are filled with sand to equalize the strain and absorb the acid drip.

The cells are usually connected in series and great care must be taken to join the positive terminal of one to the negative terminal of the next, and so on. If a mistake is made in connecting a cell it will be ruined when the charging current is turned on. The best indi-

cation of the polarity of the plates is their color. The positive plates are a light brown when discharged and a chocolate color when charged, while the negative plates vary from a light to a dark gray.

Before placing the plates in the cells, carefully examine and remove any foreign substances that may have lodged between them. See that the hard-rubber insulators are properly spaced and that the positive plates do not come in contact with the negative ones. Also inspect the jars for cracks that might allow the electrolyte to leak out. The cells should be perfectly clean and the plates should clear the bottom from one to six inches, depending upon the capacity.

If the cells are filled with electrolyte before they are permanently connected together, it is a good plan to test the polarity of each cell with a low-reading voltmeter before making the permanent connections. Or the polarity can be determined by dipping wires leading from the two terminals in dilute sulphuric acid, the one from which the most bubbles of gas arise being the negative.

In small cells the connections are made by clamping or bolting the projecting lugs together. The connections should be scraped bright and clean and the bolts set up as tightly as possible. Then paint with asphaltum to prevent corrosion, and cover with okonite tape. A better method is to weld or "burn" the lugs together. If the terminals are to be burned together they should first be scraped free from dirt and oxide. A convenient scraper can be made by fastening a triangular piece of sheet steel to a suitable wooden handle. For soldering flux, use ordinary tallow. Never use acid or soldering salts, as joints made with these fluxes are likely to corrode in the course of time.

The method of welding the lugs together will, of course, depend somewhat on their size and shape. A convenient method on moderate-sized cells is to butt the two connecting lugs that are to be welded together. These lugs should be chamfered off on their top edge so as to leave a V-shaped channel where they butt together. A sheet-iron trough is then bent up having a cross-section the same as that of the terminals. This trough is then slipped over the lugs from the bottom side, is held in place with a clamp and serves to keep the molten lead in place while the lugs are being burned together.

Hydrogen gas gives the best results, but if it is not obtainable, ordinary illuminating gas may be used. If hydrogen gas is used, make sure that all of the air has been expelled from the generator before attempting to light it, since if there is any air present there is danger of an explosion. The hydrogen gas is tested for the presence of air by filling a test tube with water and inverting it in a dish of water. The test tube is then filled with gas by means of a rubber tube which is connected to the hydrogen generator, the free end being pushed up into the mouth of the test tube. As the gas fills the tube it will force out the water. When the test tube has been completely filled, remove it from the basin, keeping it inverted all the time, as hydrogen is much lighter than air, and test with a lighted match. If the gas is free from air and safe to use it will burn with a steady, almost colorless flame. If there is air present, however, the gas will explode with a sharp noise when the match is applied.

The solder should be pure lead, as tin is attacked by the acid fumes. It should be melted off the sticks and allowed to flow into the V-shaped trough between the ends of the terminals. At the same time the ends of the lugs should be kept near the melting point. Great care must be taken not to entirely melt the ends of the lugs.

Another method of connecting the terminals is to wrap a strip of lead around the terminals and put a sheet-iron mold or trough outside of this and then pour in melted lead. The lead strips must be scraped clean to insure a good joint.

The wiring for the battery room should be, preferably, lead-covered cable. If this is not used there is danger of corrosion, and liability of some of this corroded copper falling into the cells, which would be very injurious.

Care should be taken not to have any iron hooks, braces or other pieces of metal project over the cells, as there is great danger of contamination by the falling of corroded material into the cells.

For convenience in inspecting the cells a small portable incandescent lamp may be provided. Special lamps are obtainable for this purpose which are flat so that they may be inserted into the electrolyte between the plates and the jar. This lamp should have sufficient rubber-insulated flexible cord to reach to all parts of the battery room.

The battery switchboard, which must be located outside the battery room usually forms a panel of the main switchboard. It should be equipped with a voltmeter, ammeter and device for regulating the charging voltage. In installations where it is not convenient to regulate the charging voltage by varying the dynamo voltage, resistance boxes are used for that purpose. Or in large installations a motor-generator set may be used, this being the most efficient form of regulation.

It is also essential to provide both overload and reverse-current circuit-breakers. In case of a heavy overload or short-circuit the battery would be injured if there were no protecting devices present. In small installations inclosed fuses may be substituted for the overload circuit-breaker. The function of the reverse-current circuit-breaker is to prevent the battery current from flowing back over the charging circuit in case the generator voltage should fall below that of the battery during the charging period.

Electrolyte

Concentrated sulphuric acid (oil of vitriol) is much too strong for use in storage batteries and it is, therefore, necessary to dilute it with water in the ratio of about five parts of water to one part of acid.

Commercial sulphuric acid will not do for battery work as it contains many impurities, such as iron, arsenic, copper, chlorine, etc. Use only chemically pure acid (symbol C.P.). The water used must be distilled as ordinary river or well water contains injurious impurities. Both water and acid should be kept in tightly-stoppered glass carboys, to prevent the introduction of impurities. If the distilled water is stored in barrels there is danger of its absorbing organic material from the barrels. Mix the electrolyte in a large earthenware or glass receptacle. Pour the acid very slowly into the water as there is considerable heat generated. *Never pour water into the strong acid*, as there is great danger of the operator being burned with the acid which will fly in all directions. *Always pour the acid into the water.*

The proper specific gravity of the electrolyte will de-

pend somewhat on the type of battery and the purpose for which it is to be used. In ordinary stationary installations a specific gravity of 1.200 is used while in automobile and portable batteries the specific gravity goes as high as 1.300. The advantage of a high specific gravity is low resistance, but there is great danger of the plates being injured by sulphating if the gravity is run too high.

The mixture should be allowed to cool to 60 deg., and then be brought to the proper specific gravity by the addition of a small quantity of acid or water as the case may require. Always see that the electrolyte is cool (60 degrees F.) before pouring into the cells, it being a good plan to carefully prepare the mixture twenty-four hours before it is wanted.

Tests for Impurities in Electrolyte

It is very important that the acid for making the electrolyte be chemically pure and it is recommended that each carboy of acid be tested for impurities. It is also a good plan to test the electrolyte in the cells once a month, as it may have been contaminated by the corrosion of iron fittings near the cells.

Copper salts also find their way into the cells in a similar manner. Nitric acid and chlorine may be present in the new plates in small quantities.

In case any impurities are found in the electrolyte it should be drawn off, the cells and plates washed out with pure water and fresh electrolyte added.

Test for Hydrochloric Acid (Chlorine)—To a small quantity of the diluted electrolyte add a few drops of nitric acid (HNO_3) and then add two or three drops of silver nitrate ($AgNO_3$). The formation of a white cloudy precipitate indicates the presence of chlorine in some form.

Test for Nitric Acid—A very sensitive test for nitric acid, is to mix a solution of diphenylamine ($NH(C_6H_5)_2$) in concentrated sulphuric acid (H_2SO_4) and add it to the sample under test, the presence of nitric acid will be indicated by a blue color.

Test for Iron—Fill a test tube with the diluted electrolyte and heat it to the boiling point, add several drops of concentrated nitric acid (HNO_3) and boil again. Repeat this operation two or three times. When the solution is cold add a few drops of potassium-sulphocyanide (KCNS) which will color the solution a deep red if there is any iron present.

Test for Copper—To a diluted solution of the electrolyte add ammonium hydrate (NH_4OH or common ammonia) until the resultant mixture gives an alkaline reaction. A deep-blue color indicates the presence of copper.

Test for Arsenic—To a diluted solution of the electrolyte add an equal portion of hydrogen-sulphide solution (H_2S). A yellow precipitate indicates the presence of arsenic.

If the electrolyte has been previously used in batteries there is likely to be a black precipitate, due to the presence of lead, and often the commercial acid contains a little lead which does no harm. In making the foregoing tests, it should be kept in mind that the reagents used must necessarily be pure or the results obtained will be unreliable. Use only those reagents that are labeled chemically pure.

Transformer Frequencies

Any transformer designed for a given output and frequency can be operated on a higher frequency with a slight increase in efficiency. On a lower frequency the efficiency is decreased and, therefore, the output for a given size. Transformers of modern design usually have sufficient capacity to be operated on half frequency at full-load rating without overheating. This is effected to a large extent by the location. If the transformer is located where the surrounding temperature is high and has poor ventilation it might reach a dangerous temperature, or if the surrounding temperature is normal and the ventilation is good the transformer may operate satisfactorily so far as being affected by excessive heating.

If the frequency is reduced from 60 to 25 cycles a safe practice would be to work the transformer at about 90 per cent. full-load rating for ⅓ kw.; sizes from 4 kw. up, about 95 per cent. of their full-load rating. A better method would be to run a heat test for about 8 or 10 hr. at the reduced load, the rise in temperature of the coils should not exceed 104 deg. F. by thermometer, or 122 deg. F. by resistance rise.

A transformer working continuously under the above conditions will soon use enough power to pay for new apparatus, due to the lower efficiency.

Static Charges on Belts

In the June 10 issue, Mr. Chase states in a letter that he has had much to do with belts in the past 16 years but has never known a case where static electricity could not be cured by treating with "Cling-Surface." It is very evident from this statement that his experience with different conditions has been limited; for I have seen several cases of static electricity that Cling-Surface would not touch.

When the static charge is caused by slipping of the belt, then, oil, Cling-Surface, or anything else that will remove the cause, will also remove the effect. Under other conditions, however, it is of no benefit, whatever. For instance, I ran a high-speed engine and generator having two belts, one running on top of the other, which necessitated a certain amount of slippage; this and the belts flapping together running at a very high speed caused them to carry a heavy static charge that Cling-Surface would not cure but made all the worse.

In another case, I ran a high-speed engine belted to a shaft that passed very close to the boiler safety valve, when the boilers were blowing, the belt would become heavily charged and the only cure for this case was to ground it or to stop the boilers from blowing.

Stockett, Mont. R. S. Hart.

The following communication was received by a La Crosse (Wis.) electrical firm from a farm customer. The son of the soil, it seems, had ordered a lamp fitting while under an impression somewhat similar to that of the Kansas farmer who bought a motor to do his farm work, although there wasn't a power wire within 25 miles. The Wisconsin agriculturist "came back" as follows: "Dear Sir this letter is to acknolage to you of the recept of your two ball adjusters but in addition I will make you understand that I misunderstand you. I thought that it was a lamp by itselph and not a aparatus which is of no use to me as I have no curent of electrice so you see. I want to send them back to you again and you send my money back to and nothing more to say your trully." —"Electrical World."

GAS POWER DEPARTMENT

Lignite Suction-Producer Troubles

By George W. Muench

The operation of a producer is difficult compared with the operation of a steam plant, because a producer does not allow the operator to watch his fire, and, therefore, he does not know what is going on inside, except through the action of the engine and the appearance of the gas flame at the try-cock. The anthracite producer is the simplest to handle. The lignite producer requires more skillful handling because of the poor grade of fuel, large amount of ash, and the auxiliary apparatus which separates the tar from the gas.

The following troubles and their remedies have come within the experience of the writer and may help operators who are having their troubles and who may not have had the opportunity to study the producer in detail.

Lignite being an extremely low-grade fuel is high in volatile matter, and usually high in ash. These two items must be kept in mind continuously when operating a lignite producer. The ash may be as low as 3 or 4 per cent. or it may be as high as 50 per cent. Western lignites especially adapted to producer use average about 12 to 18 per cent. ash. However, lignites with ash as high as 40 per cent. have been used successfully. Being high in ash this fuel must be worked frequently while the plant is in operation to prevent the ash bed from getting too deep.

It is practically impossible to tell an operator how often his producer must be worked, as it depends on the load, the kind of fuel and the type of producer. Again, some plants operate 24 hr. per day every day in the month, while others operate only 8 to 10 hr. and give plenty of opportunity on Sundays for general overhauling and repairing. It is, of course, the continuously operated plant that requires the most skillful and careful handling. The lignite suction producer operating 24 hr. continuously for some weeks or months, using lignite that does not clinker badly, need not be worked oftener than once every 5 to 8 hr., depending on the variation in the load. Where possible, it is well to work the producer during those periods when the load is a minimum. Working the producer with full load must be done carefully, as too much air will weaken the gas so much that the engine will slow down. It often helps to slightly advance the spark on the engine while working the producer, as the advanced spark will take care of the weakened gas. This, of course, applies to cases where by "working the fire" is meant slicing across the grates with bars through the poke holes. Where a producer is equipped with shaking grates it may not be necessary to work the fire otherwise than merely shaking the grates, and, therefore, no air will enter to weaken the gas.

Handling of the ash can ordinarily be accomplished without much trouble, yet the writer knows of cases where the air entering through the ash door while removing the ashes would weaken the gas enough to cause the engine to slow down. If such is the case the ashes must be removed as rapidly as possible and a small amount at a time. When operating only part of the day ashes had best be removed after shutting down in the evening.

The common trouble with many lignites and the trouble that causes the hardest labor, unless prevented in time, is clinkering. Lignites vary greatly as to their clinkering qualities, even though their proximate analyses be practically the same. Some require very little steam while others require considerable to keep the clinkers soft. It is of the most vital importance to give a producer the necessary amount of steam, yet it is of just as great importance to prevent an excess of steam. An excess will cause too low a fire temperature, and also often too much hydrogen in the gas, which will cause premature ignition in the engine. In case of decidedly varying loads the steam should be watched unless supplied automatically.

When clinkers form and fuse to the firebrick lining of the producer, they must be loosened by poking from the top, and broken up as much as possible, so that they will readily work down to the grate. In poking from the top care must be taken not to injure the lining. When the clinkers have been loosened and worked down to the grate, they must be removed by working through the poke holes at the grates. All this poking and drawing clinkers off the grate must be done very carefully as a slight excess of air will decidedly affect the running of the engine. In case the producer is so badly clinkered that it will require several hours of hard work to remove them, it usually pays, where possible, to shut down the engine and work at the clinkers until removed; then a few minutes blowing of the fire will put the producer in good condition for satisfactory operation. Care must be taken not to work the fire too much, as most of the fire may be worked off the grates before all the clinkers have been removed.

One result of clinkering is the formation of holes in the fire. These cause burning of the gas in the producer, due to excess of air in this part of the fuel bed. This, of course, causes weak gas at the engine on account of too much carbon dioxide (CO_2). Holes may be formed by a caking coal, but this trouble is not so common with lignites. Both clinkering and caking can often be reduced to a minimum by working the fire oftener. Still another cause of holes is the use of coal which consists of too large lumps. When this is the case, the fuel has a tendency to hang in the producer and not feed down as readily as it should.

The writer recalls an instance where such large lumps were used that the fuel would not feed through the charging hoppers. The firemen were in the habit of filling the hoppers with the lid open, then lower the bell, and ram the lumps into the producer with a rod. This not only weakened the gas on account of too much air getting in, but in one instance a flame shot out through the hopper

while forcing through the large lumps and badly burned the operator.

The best size when using lignites is either nut or pea, mixed nut and pea gives very good results, and is readily handled in the producer. Pea alone has the disadvantage of packing more than the nut coal, and, therefore, puts the entire system under a greater suction. Unless handled carefully the pea coal will not give as economical results as nut coal, as considerable unburned coal will run through the grates or off the edges of the grates with the ash.

Too low a fire will cause the grates to overheat. The ash bed should be deep enough to keep the high-temperature zone away from the grates. Too hot a fire at the grates may also cause clinkering between the grate bars and thus prevent the free shaking of the grates as well as prevent the ash from working through. The usual cause of too low a fire is overworking the fuel bed.

The fire being too high causes overheating of the producer, which in turn causes the clinkering, and burning of the gas inside the producer. The immediate remedy is a thorough working, especially at the grate, to remove enough ashes to lower the hot zone. Too high a fire is also often caused by an overload on the producer. If the fire continuously gets too high the producer must be worked oftener at the grates; usually if the fire is in good condition, merely rocking the grates occasionally will keep the fire low enough.

The proper depth of the fire varies with different plants, depending on the length of the working day, the type of producer, the load on the producer, the quality of the coal and the method of working the producer. A careful and wide-awake operator will soon determine what depth of fire gives the best results for his plant.

An occurrence which may puzzle the operator, is the ash piling up in the ashpit, deep enough to block the air-intake pipe opening. When this happens the air supply to the producer is shut off and will cause the engine to gradually slow down, and unless remedied will finally stop it. If the plant is equipped with water-column gages the trouble can immediately be located at the producer itself by the high suction shown by the gage column. This is not a common occurrence, however, and in many types of producers could not happen.

The one thing which may cause more worry with a lignite producer than any of the aforesaid troubles is tar. At the engine this is a serious matter and must be remedied. The gas at the engine should not contain more than 0.0205 gr. of tar per cu.ft.

The first place one would naturally look for trouble when too much tar gets to the engine, is the washing apparatus. Tower scrubbers are simple in operation, but must be furnished with plenty of water. The operator must watch this water supply closely. The same holds true, with rotary, or centrifugal, gas washers. The amount of water necessary to thoroughly wash the gas is about 2 gal. per hp. per hour. When rotary washers above are used, the power necessary to wash the gas is about 4 to 5 per cent. of the load on the producer. Dirty gas may be due to insufficient power for cleaning. The gas washer may run too slow, due to improper pulley sizes or too small a driving motor; the higher the speed of the washer the more efficient will be its operation.

Tar in excess may also be due to poor condition of the fire. The fire should be hot enough to change much of the tarry matter into fixed gases and thus prevent the scrubbing apparatus from being overworked.

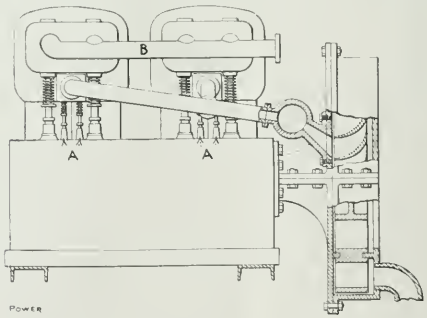
In regard to producer plants which do not give 24-hr. service but shut down for the night and Sundays, several points of special note are worth mentioning. Of course, the gas forming escapes through the purge when not operating. A slight draft should be maintained through the producer and up through the purge. If shut off entirely it will require too much time for blowing the fire when gas is wanted for running. The amount the air valve should be kept open can only be determined by trial; if kept open too much the standby loss will be too great. This must be avoided, as one of the strong arguments in favor of gas power is the small standby loss compared with steam.

If steam be supplied to the producer from some outside source, it should be shut off after shutting down the plant for the night. This should not be forgotten as the steam will deaden the fire and may extinguish it entirely.

It may not be good policy for an operator to be continuously looking for trouble, yet the operator who is always on the lookout for weak gas at the engine and poor fire conditions, is the one who will have the best operating plant.

Power from the Exhaust

That the present-day automobile engine has reached a high state of perfection is generally conceded; hence further improvement must be sought outside of the design of the engine itself. The idea of utilizing the high velocity and pressure of the exhaust gases from a gasoline engine for producing additional power has been worked out by Michael M. Sullivan, of Poughkeepsie, N. Y. His scheme consists in replacing the flywheel with a turbine wheel similar in many respects to that of a single-phase steam turbine. The shape of the blading is such, however, as to utilize both the impulse and the reaction effects. The casing surrounding the runner is bolted to the engine frame.



Turbine Wheel Attached to Gasoline Engine

The pipe which conducts the exhaust gases to the turbine attaches to the engine cylinders at a point near the end of the piston travel, and the gases pass through ports in the cylinders at this point. Valves A.A. working off the regular camshaft, are provided so as to shut off communication with this pipe on the suction and com-

pression strokes. In order to avoid any back pressure on the engine the regular exhaust valve and exhaust manifold *B* are provided, so that on the upward stroke the engine exhausts against the atmosphere. The valves *A* are timed to open earlier than the regular exhaust valve. A spherical chamber is provided in the pipe leading from the engine to the turbine and serves in the capacity of a receiver.

A brake test of a small four-cylinder engine fitted in this manner, which the writer witnessed, indicated that the turbine added from 15 to 30 per cent. to the power, depending upon the speed.

At present the arrangement lacks refinement, but better results could undoubtedly be obtained by employing several nozzles through which the gas could be distributed around the periphery of the wheel. This would tend to equalize the thrust and give a more uniform turning moment. It is understood that the inventor contemplates doing this in his next machine, which will comprise a much larger engine and which no doubt will give more conclusive results.

CORRESPONDENCE

Saving in Power Cost with a Gas Engine

The choice of motive power for a moderate-sized drug and spice mill located in this city, has just been decided after over a year's experimentation and investigation. A 25-hp. reciprocating steam engine which previously ran the freight elevator, mills, grinders, etc., became so obviously uneconomical and in need of extensive repairs that the owners decided to scrap it. Temporarily, a 5-hp. electric motor was installed to run the freight elevator and carry on the most essential parts of the plant. The building itself contains six stories with shafting and machinery on the third, fourth, fifth and sixth floors. Connection with the old steam engine in the basement was obtained through belting with a jackshaft located on the second floor. The motor was installed on the fourth floor and the greater part of the shafting was cut off so that only enough remained for driving the elevator, a tablet machine and a few other small machines.

The motor remained in operation for four months, during which time the cost for electricity was $96.60. The charge was based on a rate of 12c. for the first 23 hr. use of the maximum demand and 9c. for all power used in excess of 23 hr. and not exceeding 103 hr. use of the maximum demand. Further deductions were in order for greater amounts of power, but were not applicable for the small amount of power actually used in this installation. The average maximum demand amounted to about 5 kw. during this time and, as it will be noted, was rather high for the total amount of energy consumed. The high demand charge was brought about by the large amount of power needed for starting the shafting and in running the elevator for short intervals.

It was finally decided that a gas engine would be preferable for supplying permanent motive power. Consequently, a 20-hp. second-hand gas engine in excellent condition was installed on the second floor to replace the old jackshaft previously driven by the steam engine. The entire equipment was belted to the gas engine and the new installation started on Oct. 16, 1912. By Mar. 27, 1913, the amount of gas used amounted to 122,0000 cu.ft. At the prevailing rate of 80c. per 1000 cu.ft., the cost for gas was $97.60. The cooling water used was obtained from the city mains at a cost during the specified time of $20. This cost for water is not chargeable to the engine cost alone, inasmuch as the hot water from the engine-cylinder jackets was used in carrying on other operations connected with the establishment. The average cost per month for gas and cooling water was therefore not over $21 per month against $24 for electric power. The work done during this time with the gas engine was as follows:

At least double the tablet work and press work were put through; 4200 lb. of herbs were cut in a machine which had never been operated at all by the motor; 10,000 lb. of material was finely ground and these grinders alone took at times over 12 hp. Moreover, the elevator was necessarily run considerably more during this time for conveying these materials from floor to floor.

The rate schedule for the electric energy places the motor under a considerable disadvantage because the demand charges constitute such a large proportion of the total cost. Had the actual energy used been considerably greater, that is, if there had been a steady load for long hours without a considerably greater increase of power required for starting the machinery, the motor could have competed with the gas engine on a more comparable basis. The owners also claim that the gas engine is less expensive than the steam engine. However, as the building requires a boiler installation for heating purposes and as the old steam engine was in such poor condition there is no fair basis on which to judge the merits of the gas engine and an uptodate steam engine.

F. R. Lufkin.

Boston, Mass.

Dust Determinations for Blast-Furnace Gases

As an interesting addition to the article in Power of May 13, 1913, on taking dust samples in gases, it may be noted that in the tests made in the South African mines by A. McArthur Johnston (Journal of the Chemistry, Metallurgy and Mining Society of South Africa, May, 1912), it was decided that powdered sugar made the best dust collector. The filter bed was made by coarsely crushing lump sugar, and using that which failed to pass through a 90-mesh (0.006-in. aperture) sieve. The filtering layer was made about two inches thick and was held in place in a glass tube by copper or brass gauze. It should be slightly moistened to aid in the retention of dust, but not sufficiently to cause caking. This point, however, must be learned by experience.

To estimate the dust, after the air was aspirated through the sugar, the sugar was dissolved in distilled water, and then the solution filtered through a tarred filter, or on an asbestos mat in a gooch. The weight found after drying represents the total dust present. Incineration will then give a loss, the organic matter.

Donald M. Liddell.

Elizabeth, N. J.

HEATING AND VENTILATION

Waste Heat from Gas and Oil Engines for Heating Buildings

In the report of the committee on steam heating presented to the National Electric Light Association, E. F. Tweedy showed that the heat available from gas and oil engines is only about 5 per cent. of that from the exhaust of ordinary high-speed, single-cylinder engines.

Several facts have militated against the more extended use of this waste heat for building heating. One difficulty has been the serious corrosion of the heaters used for extracting the heat in the exhaust gases, by the sulphurous-acid gas and moisture present in the exhaust. In certain later types of heater, however, cast iron has been substituted for steel, with the result that this corrosive action has been lessened.

On account of the high temperature of the exhaust gases—usually ranging from 600 to 1000 deg. F.—it is desirable to place the exhaust heater or boiler as near as possible to the exhaust outlet of the engine to reduce the length of exhaust piping. It is not practicable to lag the exhaust piping with heat-insulating material, as overheating of the engine would usually result; as a matter of fact, it would be desirable in most instances to water-jacket the exhaust piping between the engine and the heater.

Another reason for the limited extent to which the heat in the exhaust and in the jacket water has been utilized for building heat is the comparatively small amount of heat available from these sources as compared with the amount present in the exhaust of a steam engine carrying a similar load.

In Fig. 1 curves are given showing the approximate input of heat to gas and oil engines per kilowatt-hour of output. In this figure, curve *A* is derived from a test made upon a 75-hp. low-pressure oil engine, operating on solar fuel oil of 17,240 B.t.u. per lb. (high). The heat inputs per brake horsepower at various loads have been multiplied by 1.5 to obtain the heat inputs per kilowatt-hour. Curve *B* represents the average heat economy per kilowatt-hour for gas engines of various sizes, as given in a paper read by E. D. Dreyfus before the Pittsburgh Railway Club. Curve *C* is derived from a test made upon two Diesel engines. The points shown by circles are for a 300-hp. engine operating on fuel oil of 19,419 B.t.u. per lb. The points shown by crosses are for an engine of 225 hp. The heat inputs per brake horsepower have been multiplied by 1.5 to give the heat inputs per kilowatt-hour.

Fig. 2 shows the distribution of heat in a 225-hp. Diesel oil engine, the input of heat to which, at various loads, is given in Fig. 1. From Fig. 1 it would appear that in the Diesel engine of medium size an average heat input may be expected from 50 to 100 per cent. of rating, of about 13,500 B.t.u. per kilowatt-hour of output; while for the gas engine the average heat input through this range of load is probably in the neighborhood of 18,000 B.t.u. Individual engines of both types may vary considerably from these average figures. Fig. 2 shows that the heat represented in the exhaust, together with that lost in radiation and friction, averages about 50 per cent. of the total heat input from one-half to full load for this particular Diesel engine. Probably a figure of 40 to 45 per cent. for the heat in the exhaust alone would represent a fair average value for the Diesel engine in ordinary operation. The percentage of heat in the exhaust of the average gas engine may probably be taken at from 30 to 40 per cent. of the total heat supplied to the engine. The relative amounts of heat carried away by the exhaust and by the jacket water may vary to a considerable extent, in either type of engine, with the method of operation. Based upon the foregoing figures with either of these two types of engine there would be in the neighborhood of 6000 B.t.u. available in the exhaust per kilowatt-hour of output.

The jacket water ordinarily carries away from 20 to 30 per cent. of the total heat supplied to the Diesel engine and from 25 to 40 per cent. of the total heat of the average gas engine. These percentage figures will, of course, vary to a considerable extent, according to the amount

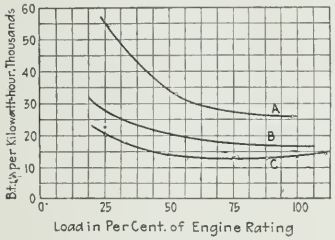


Fig. 1. Total Input of Heat to Gas and Oil Engines per Kilowatt-Hour of Output

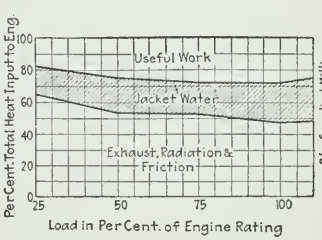


Fig. 2. Distribution of Heat in 225-Hp. Diesel Oil Engine

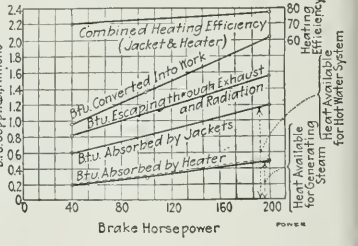


Fig. 3. Results of Test on Exhaust Heater Connected to 200-Hp. Gas Engine

of cooling water supplied and according to its temperature.

Two distinct methods of utilizing the waste heat of gas and oil engines present themselves:

1. Heating water by means of exhaust gas either by (a) raising the temperature of the water discharged by the jacket of the engine, or (b) raising the temperature of other water, such as that in a closed hot-water heating system, without making any use of the heat in the jacket water.

2. Raising steam by means of the exhaust gases, using as boiler feed either (a) the jacket water, or (b) other water, with no attempt to utilize the heat contained in the jacket water.

Where large quantities of hot water are required for industrial purposes 1. (a) affords a means of utilizing a large percentage of the waste heat of a gas or oil engine. When a building is to be heated by means of hot water, this method would not be practicable, and 1. (b) would be the method employed.

If it were desired to generate steam in small amounts for industrial purposes, the method shown under 2. (a) might be used, although it would entail considerable complication and materially increase the cost of installation. Moreover, the saving in heat would not be great, inasmuch as only a small percentage of the jacket water may be evaporated by the heat in the exhaust gases. When steam is to be employed as the medium for heating a building 2. (b) affords the most practical method of utilizing waste heat, and this system would, under ordinary circumstances, be the most desirable one to adopt.

Fig. 3, which is reproduced from an article in POWER (issue of Apr. 11, 1911), by E. D. Dreyfus, gives the results of a test upon an exhaust heater connected to a 200-hp. gas engine. The amount of heat reclaimed by this heater for the generation of steam was shown by this test to be in excess of 20 per cent. of the heat supplied to the engine at all loads. This would be sufficient in amount to generate about 3 lb. of steam per kw.-hr. at full load, and approximately 4 lb. per kw.-hr. at 50 per cent. of full load.

The approximate pounds of steam per kw.-hr. available in the exhaust of a steam engine and that available from heat in the exhaust of a gas or oil engine are as follows:

Simple automatic engine	60
Single-cylinder Corliss engine	42
Corliss noncondensing compound engine	33
Gas or oil engine, exhaust used for raising low-pressure steam	3

Accordingly, it will be seen how insignificant is the amount of steam that may be generated from the waste heat in the exhaust of the average internal-combustion engine when compared with the amount of exhaust steam obtainable from the ordinary simple automatic engine.

Possibilities of Hot-Water Heat*

Hot-water heat has many possibilities from a financial standpoint, but many things affect the earning power of the plant, among which are the design of the plant, the way it is put together, the relation between the electrical load and the heating load, the particular way that the bookkeeper figures the profits or keeps the books, the rate charged for heat, the method used in figuring radiation and the condition of the pipe lines.

*Abstract of paper read by N. M. Argabrite before the National District Heating Association, Indianapolis, May 27, 1913.

Some engineers turn the exhaust from an engine into an open heater or drum equipped with spill pans, and by splashing the return water of the heating system down over these pans absorb the heat in the steam. Another method is to use a set of small upright inclosed heaters with copper or brass tubes, passing the steam into the chamber and the circulating water through the tubes, and allowing the condensate to run out through a drain line.

An improved method over the first mentioned is to exhaust into a jet condenser, thus forcing the water to take up the exhaust steam and oftentimes giving a fair vacuum on the prime mover.

A better method is to exhaust the steam from the prime mover into an oversized heating condenser. The heating water is circulated through the cooling chamber and a dry-vacuum pump and hotwell pump are used to obtain all possible vacuum on the prime mover. The condensate is saved for boiler feed.

The way a hot-water heating plant is put together has much to do with its success. Many spill-pan systems come to grief from cylinder oil working its way into the heating mains, then into the services and radiators and eventually clogging up the system, although an efficient oil separator will tend to eliminate the trouble. This same objection may be offered to jet-condenser systems.

The relation between the electrical load and the heating load greatly affects the earning capacity of a hot-water plant. To say the least there is no large amount of money in the hot-water heating business—or steam either, for that matter—when the plant has no other product, such as electricity. It stands to reason that the more heat that can be obtained from exhaust steam the better from a financial standpoint. It then becomes a question of proportioning the heating plant to the electrical load, or *vice versa*.

A heating system designed to absorb all the exhaust in November will surely have three months of live steam use. A certain amount of live steam is not a bad thing when its use does not come too often, and still allows the spring and fall steam to be turned into more money, but the best advice to the man with a hot-water plant requiring too much live steam is to get busy and load down the electric end. It is possible at this day and age to put one electric consumer on the lines for every five people in the city.

The objection might be raised that the lighting load gives peak customers who would furnish relief only for a few hours per day, but right here is one of the main advantages of hot-water heat; namely, that the heat does not pass off immediately as with steam. The pumps can be stopped in the dead of winter for several hours and the customers will not suffer. The author had one line off last winter from 2 p.m. to 6 p.m. and nobody on the line had complained up to 15 min. of the time service was resumed.

The ideal relation between electric and heating loads is found in larger cities, where there are one or several other plants working in connection with a heating plant or plants. With these conditions the electric load becomes elastic and can be made to fit the heating load.

The particular way that the books are kept has much to do with the plant earnings, and can in many cases make the hot-water plant a paying or losing investment. Is the heating plant charged with all coal and all plant

labor, giving credit for current at wholesale or retail rate? Some may think the coal cost for summer months should be wholesale and others that it is only fair to charge heating with all above the summer kilowatt cost. If this is done, then what about the larger peak in winter calling for more engine units which often raise the cost per kilowatt-hour? Also, what about the hot-water plant which really reduces the cost per kilowatt-hour by making an otherwise noncondensing plant condensing? This is another important advantage of a hot-water system.

Hot-water heat generally sells by the square foot of radiation per season, and the rates for this service range from 15 to 25c. per sq.ft. per season. Naturally a great deal depends upon this rate and upon how fair a rate a company has for its location. A 25c. rate in Minnesota is no better than a 20c. rate in Ohio, all other conditions being equal.

The condition of the pipe lines has much to do with the overall economy. A small leak in a hot-water main will eat up many feet of pipe each season. Most of the pipe depreciation takes effect on the outside and is caused either by leaky pipes or by outside water getting into the boxing, principally the former. Many hot-water men brag about doing heating with water at the temperature at which the steam man's condensate is going to the sewer, but that same man may have a make-up pump in his plant, supplying as much make-up water as is going into the boilers or even more.

In the opinion of the writer, the greatest possibilities in hot-water heating lie in improving and bringing uptodate the present systems.

Among the possibilities referred to are the following: Cleaning out some of the wasteful auxiliaries; getting rid of open heaters and installing heater condensers, thus making the plant condensing; installing thermostatic control on the services; improving the pipe insulation; reducing excessive circulating pressures; closing every leak on the system, and many others.

In looking over the pump room of a hot-water company the author counted ten steam pumps going at one time. Some of these pumps could have been easily eliminated. It is on this point that most companies make their greatest mistake. The man in charge of the above mentioned plant said that the extravagance of these pumps made no difference as they needed the steam for the heat anyway. A test upon his circulating pumps showed a steam consumption of about 150 lb. per hp.-hr. How many operators would run a generating set very long if it took half as much steam? It takes between 25 and 40 hp. to circulate water for a system of 100,000 sq.ft. Suppose the pumps were changed to electric drive. Motors would then be employed requiring about 40 lb. of steam per kw.-hr., or 30 lb. per hp.-hr. This would save about 120 lb. of steam per hp.-hr., meaning for an ordinary 100,000-ft. system using 30 hp. about 3600 lb. of steam per hour. This quantity of steam will make in the average small plant about 90 kw. per hr., which will mean in 200 days, 432,000 kw.-hr. Kilowatts have a market at some price. If the wasted steam mentioned above is needed on the heat peak it will not be required during the remainder of the season. Taking the average income from power at about 3c. per kw.-hr., 432,000 kw.-hr. at 3c. would bring $12,960, 6 per cent. interest on $216,000. In coal alone at $2.10 per ton the change would save $2000.

There may be many chances almost as good as the above for making large savings. It is desirable to save the condensate for boiler-feed water, to run the engines condensing and perhaps circulate the water in the system more slowly. All of these things can be done by installing a large oversized heater condenser with a vacuum pump and hotwell pump, allowing about 5 ft. of condensing surface per kilowatt of maximum load.

Assume an engine drive taking 40 lb. of steam per kw.-hr., and a daily load of 5000 kw.-hr. supplying heat to 100,000 sq.ft. of radiation. Surely a vacuum averaging 21 in. will save at least 15 per cent. of the steam needed to drive the engine. At 40 lb. of steam per kilowatt-hour and 200 days per season, 5000 kw.-hr. per day would require 40,000,000 lb. of steam. An evaporation of 8 lb. would call for 2500 tons of coal, which at $2.10 per ton would cost $5259. Then 15 per cent. of this figure would be $787.50, the amount actually saved in coal.

The condensers previously referred to are on the market and what is more they will do what is claimed for them. It is possible to get an outboard temperature of 130 deg. with 115-deg. return water and have a 25-in. vacuum; 140-deg. water, 120-deg. returns, 23½-in. vacuum; 150-deg. water, 130-deg. returns, 21½-in. vacuum; 160-deg. water, 140-deg. returns, 18½-in. vacuum; 175-deg. water, 150-deg. returns and a 15-in. vacuum.

These figures can be bettered by slowing down the circulation and bringing the returns back colder.

Heating and Ventilating in Europe

In Germany, states a consular report, during the last 10 years the installation of hot-water and steam heating, and for large buildings the necessary ventilating facilities in conjunction therewith, has made enormous strides.

The high cost of raw materials, both for combustion and the heating plant itself, has necessitated greater economy in installing and daily operation; hence the obvious reason for their greater advance along these lines. Scientific study has enabled Germany advantageously to compete with all foreign competitors, not only in their own country but in most others where tariff restrictions are not too great.

The fuels mostly in use are coke and a noncoking brown coal (lignite), the former being a byproduct of gas works and reducing ovens and the latter a very cheap form of soft coal low in heat units. The cheapness of this fuel has resulted in overcoming the difficulties of obtaining efficient combustion with such a poor class of fuel.

All towns and cities are governed by a general and very strict smoke ordinance, which applies to house heating as well as power boilers. At the same time all cheaper classes of fuel, especially of the lignite variety, tend to give a noxious and easily detected smoke when the combustion is not complete. Hence great difficulties have had to be overcome in manufacturing boilers to give satisfactory and economical service and at the same time to comply with the laws governing their operation.

House-heating boilers for both steam and water systems are sold on a basis of heating surface, the average price being 50 to 70 marks ($11.90 to $16.67) per sq.m. (10¾ sq.ft.) heating surface, depending on the size and quality. Radiation, on the same basis, costs 6 to 7 marks ($1.43 to $1.67) per sq.m. heating surface. It is usual to assume an additional 20 per cent. to cover the cost of installation.

EDITORIALS

The Steam Turbine for Auxiliaries

Time was—and not long ago—when the use of steam turbines for driving auxiliaries was considered to be poor engineering because of the high steam consumption of these units. There are those who still believe that the small turbine is too wasteful of steam to warrant its use.

The experience of engineers in large plants where the auxiliaries are numerous, leads them to favor the turbine for auxiliary drive because its overall economy is better than is practically possible with reciprocating engines. While the steam consumption of the turbine is usually greater, its low cost for maintenance, oil and repairs, and, consequently the lesser amount of skilled attention required for its successful operation, offset the higher water rate. It must be remembered, too, that the exhaust steam from these small turbines is returned to the feed-water heater, and thus much of the heat supplied to the machines is returned to the boilers without an appreciable dead loss.

The development of the modern centrifugal pump is having a marked influence on the field of the small turbine. Centrifugal circulating and boiler-feed pumps that may be easily accommodated to turbine speeds are becoming more and more popular, not solely because of the little floor space occupied, but because they are not so subject to disorders, as those of the reciprocating type.

It is known that the efficiency of steam turbines, large or small, decreases as the blades are worn by erosion. It is important, therefore, that small turbines as well as large ones be supplied with steam that is reasonably dry. Troubles due to the erosion of turbine blades are not so numerous or costly now as they were a few years ago, owing to the use of metals that better resist the erosive action of the water.

⁂

Some Causes of Flywheel Explosions

Every little while an account is published of a flywheel explosion, the cause of which is unknown. Nevertheless, no flywheel will burst without a cause. If it is discovered a second accident from the same source is not likely to occur; if the real cause is not ascertained another flywheel accident may take place.

Few engineers realize that the rims of most engine flywheels have a velocity of approximately one mile per minute, which is considered safe. If the engine speeds up a few revolutions the rim velocity exceeds the safe limit and approaches the bursting point.

The energy stored up in a revolving flywheel is tremendous and if suddenly released, will result in widespread havoc. Under ordinary bursting conditions the rim of a flywheel has a velocity of approximately three miles per minute, which accounts for the fact that most bursting flywheels are completely demolished upon rupturing and the pieces are thrown through thick walls and for considerable distances.

The menace from flywheel explosions is unfortunately not confined to destruction to property, but generally involves the death or injury of one or more of the employees about the plant.

Governor derangement of one kind or another is probably the direct cause of more flywheel accidents than can be attributed to any other. It may be that the governor belt broke or ran off the pulleys, and the governor was prevented from operating the safety cams, because the stop pin had been left in position.

An exhibition of this kind of carelessness was witnessed just recently. The engine was new, and equipped with a safety stop, but notwithstanding the ingenuity of the inventor and the expense of making it, so that the engine would be safeguarded against overspeed, the running engineer had plugged the stop with a piece of wood, making it inoperative and defeating the purpose for which it was intended.

Overload is another cause of flywheel rupture, when the engine is belt connected. Generally the rim of the wheel is made thin and is, therefore, likely to fail, not only from centrifugal force, but from a short-circuit of the electric generator, if used, a sudden stoppage of the engine, or the sudden throwing on of heavy machines in the mill.

The greater the velocity of the rim of a flywheel the lighter it can be constructed and still prevent fluctuations in engine speed. There is a tendency on the part of the engineer to run an engine to high rim speed in order to obtain additional power from an engine and wheel designed to do less work. Such a wheel is more likely to rupture from overload than if it had been designed with a heavier rim. When speeding up an engine to obtain more work the engineer should not neglect to take the strength of the rim of the flywheel into consideration.

⁂

Public Service Commission's Power-Plant Rules

On July 1, the rules drawn up by the Public Service Commission for the protection of employees of public-service plants, for the First District of New York State (New York City) went into effect. A list of these rules was published in POWER for June 17, page 880.

Among the rules, five are especially important, namely:

(8) All stop valves on steam boilers shall be of the automatic self-closing type.

(10) All furnace doors on hand-fired boilers shall be fitted with latches or catches to prevent them from being blown open.

(12) All large main cutout stop valves shall be provided with means whereby the same may be closed from the boiler or engine-room floor or other remote point.

(13) All large steam units shall be fitted with automatic self-closing valves.

(14) All high-speed engines shall be fitted with automatic safety stops.

These rules are indeed excellent. It is to be regretted that their application is so limited. As is generally known, they apply only to public-service corporations, for the Public Service Commission has no jurisdiction over private plants. Steam boilers or engines and their piping carrying high-pressure steam are no less dangerous because they are in a plant other than a public-service plant. In fact, the opposite is true, as a comparatively greater number of serious accidents happen in manufacturing than in large power-house plants, chiefly because manufacturers are so reluctant to equip their plants with safety and labor-saving devices.

There is strong opposition to these rules in some quarters, and there are likely to be interesting developments before the commission succeeds in enforcing them in all public-service plants in the First District. Some of the more modern plants have automatic stop valves on boiler leads and on steam lines to the main units; the high-speed and other engines have automatic stops. Plants so provided will not be under heavy expense to meet the requirements of the commission's rules. But companies that have several plants aggregating one or two hundred boilers, none of which have automatic stop valves, will have to spend a goodly sum to comply with the rules. The expense of furnishing automatic valves to the boilers is not all that must be met, but it is the largest item.

It would not surprise us if some of these last named companies should object to the rulings on the ground that they are discriminatory. Their logical contention would be, as we stated, that high-pressure boilers and piping are no more dangerous in one place than in another and, therefore, the rules relating to automatic stop valves and furnace doors should apply to all plants or to none.

Such a controversy would undoubtedly lead to the commission recommending a state law embodying their rules that would apply to all plants.

A few months ago we recommended, editorially, that states or municipalities creating laws enforcing the use of automatic nonreturn stop valves, should make it compulsory to put in these valves in new installations or when remodeling an old plant or renewing a stop valve. At least they should allow a reasonable time within which the change from the old-type valves must be made. In this way no undue hardship would be worked on any plant, all would be equitably treated and the old valves would slowly but surely become obsolete.

⁂

Over-Specialization

More than in many other callings, the fascinating details which form so large a part of the engineer's work tend to make him an extreme specialist. The economical production and utilization of power is in itself a broad and rich field in which to turn one's best energies to useful account; but important as is this branch of engineering, it is a means to an end, and a keen perception of that end forms a mighty good platform upon which to stand in looking toward larger responsibilities and greater rewards.

In these days it is needless to dilate upon the value of the specialist in the doing of the world's work—the necessity for the man with deep, acute knowledge in particular and often difficult branches is self-evident. But the world also needs, and finds none too common, the man with the analytical power of the specialist and the constructive ability of the able technical executive. Those who can qualify seldom remain on jobs with no futures. How to qualify is the big problem.

A technically trained engineer has constantly to combat a tendency toward narrowness of viewpoint if he desires to cultivate a wide mental horizon. He has to avoid a complete absorption in detail to the exclusion of the larger relations of his work if he will advance along broad lines, and still he must not neglect details which are essential. The man with the capacity to see the unusual and the significant, the chap with imagination and enterprise enough to look at the relations of his own duties to the welfare of the concern as a whole is the one selected to go higher when the inevitable changes of industrial life come.

Over-specialization often leads to undue emphasis upon the importance of individual tasks in given departments; to a lack of interest outside immediately vital responsibilities; to long continued employment at stated compensation perhaps, and not seldom to final replacement before middle age is past by men with less experience in single grooves but with better comprehension of interdepartmental relations and the ability to make effective use of men with limited ideas.

The engineer should regard his department as a link in the chain—a mighty important link, but a part in the whole scheme of organization, representing, in the case of a power plant, probably not over five per cent. of the total cost of production, and the less this percentage the better, by the way. While keeping up an intense interest and activity in the detailed work of each day, he should look for their significance in the mass. If his company is given a hearing upon its rates or a stock issue before the state commission, he should try to secure the record of the testimony and study the company's operations from a new viewpoint. These records are practically always open to public use at the commission's office, but no liberal manager will deny his employees the opportunity to read such records within the plant itself, if the request is made in good faith. The engineer should make as careful a study as possible of the workings of all departments, the public policy, commercial methods and general administration of his organization; the time required will be well spent in the interests of a larger efficiency and broadened outlook.

⁂

In the past year an investigation has been made of every accident that occurred on the Pennsylvania Railroad. To give all employees the benefit of this investigation, a book has been compiled, "Safety Hints and Suggestions for the Prevention of Personal Injury Accidents," and copies distributed among them.

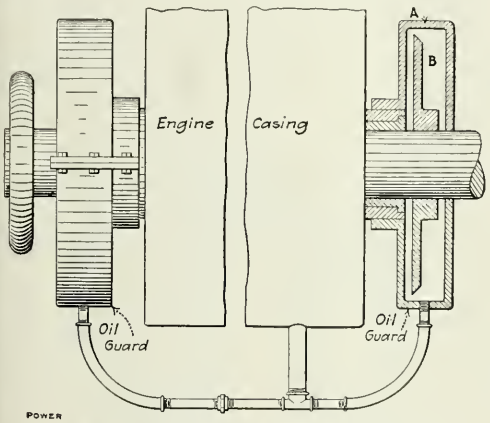
It would be splendid if some such service could be done for power plants generally. At least they may profit by this thought that is expressed in a message from the general manager accompanying the book:

"Safety in railroad operation is not a question of safeguards, but of intelligent caution constantly exercised. The ultimate aim of the safety work is to develop in each employee a sense of personal responsibility, not alone in taking measures for his own safety, but for that of his fellow employee as well."

READERS WITH SOMETHING TO SAY

Baffles Save Much Oil

In marine practice one has more or less trouble with oil that runs from the bearings, etc., down the outside of the machines, then to the deck and, unless the oil is kept wiped up, it makes an objectionable mess. Our worst trouble was with eight force-draft blowers; they were inclosed in an oil-tight casing so that the cranks, main bearings and crossheads were oiled by the splash system. These engines ran nicely, seldom needing any unusual attention, but oil would get through the sides of the main bearings and besmear the blower with oil, besides crawling along the shaft at both ends and when it reached the starting wheel it would fly off in all directions with considerable force as the blowers ran at 800 r.p.m. This was partly overcome by fitting hoods over



Crankcase Fitted To Avoid Oil Leakage

the starting wheels. The fan end was more difficult to control as the oil would get through the fan casing where the shaft went through, and the fan would throw it all over the top of the boilers. This wasted 4 gal. of oil a week for each blower and the trouble lasted for a long time, during which many devices were tried but without satisfactory results.

An oiler said that he had solved the oil problem and he produced the sketch shown. Both oil guards *A* and oil baffles *B* were made in halves so that they could be bolted together without removing the shaft fittings. The bottoms of the guards were connected to the bottom of the oil well. We had patterns made and received four sets of castings before sailing, fitting them up on board, as illustrated. This ended our troubles, besides saving nearly a barrel of oil each trip.

K. D. Granger.

Philadelphia, Penn.

[This same arrangement of baffle and casing is applicable to any shaft.—Editor.]

Pump with Hydraulically Operated Suction Valves

Discussions relative to troubles attendant upon handling hot water with direct-acting steam pumps, recalls an experience which resulted in disappointment to the inventor of a hot-water pump. An engineer had in service a duplex steam pump and receiver, handling heating returns to the boiler on a closed system. Under ordinary circumstances the mechanism operated perfectly, but peculiarly enough, with a falling boiler pressure, a condition sometimes existed which caused the pump to become vapor-bound, run away and almost pound itself to pieces. This trouble invariably occurred at night, during the engineer's absence.

After much thought and some experiment, it was determined that a vacuum was formed in the receiver when a small quantity of cold condensate was returned to the receiver. This prevented the water from flowing down into the pump cylinders, for some reason or other, which

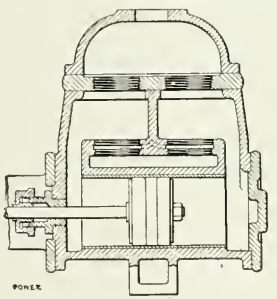


Fig. 1

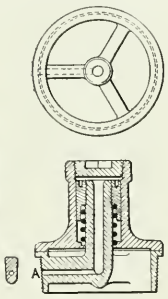


Fig. 2

Section of Pump and Details of Suction Valve

in turn caused the pump to become vapor-bound. It was reasoned that if the suction valves of the pump were automatically operated, this condition could not occur.

A manufacturer was finally found who built a pump to the inventor's design, as shown in Fig. 1, equipping the pump with automatic suction valves, as shown in detail in Fig. 2. The suction valves are hydraulically actuated, being lifted off their seat by the pressure in the discharge space at the opposite end of the cylinder, water under pressure entering at *A*, Fig. 2, and flowing into the cored ports.

Strange to say, even this arrangement, presenting a free port through which the water from the receiver could flow to the cylinders by gravity, failed to prevent the pounding. The pump operated just as badly with the automatic valves as with the ordinary pump valves, though the reason for the failure has always remained unknown. An itinerant "pump doctor" suggested piping a cold water injection line to the cylinders to condense the vapor and prevent the pump from slamming. This

expedient proved entirely satisfactory, the introduction of a very small quantity of water proving entirely adequate to stop the pump's running away.

No pump and receiver can be operated on a closed system without danger of becoming vapor-bound, no matter where the receiver may be located in reference to the pump. As a matter of experiment, a receiver 15 ft. above the pump has been tried, and it has been found that the pump could be made to run away by the injection of a small spray of cold water into the receiver. In practically every case, an injection of cold water into the pump cylinders entirely prevents this trouble.

H. B. Goodwin.

Holyoke, Mass.

Pitting of Boilers Due to Furnace?

The pitting of boilers in Chicago seems to be quite characteristic to boilers having the dutch-oven type of furnace. The object of installing this type of furnace is to eliminate the smoke, which it does after the furnace gets hot.

There are about three thousand firebricks used in the construction of such furnaces, so it is readily realized how much heat they retain after the fires are drawn or burned out. On examination of the inside of the boilers the next day or so after the fires have been drawn and the steam is down, it will be found that the heat from the furnace generates a vapor in the boiler and when the vapor condenses on striking the top plates it forms small drops of water which cling to the shell until they become heavy and drop on the bottom plates. During the time the drop is forming a chemical action seems to take place. This chemical, which seems to be heavier than the water, and wherever it drops settles on the flues or shell and pitting takes place. This action does not occur in other boilers that use distilled water, but have not that kind of a furnace.

E. Herzog.

Chicago, Ill.

A Unique Explosion

Two boilers, 60 in. by 16 ft., of the horizontal return-tubular type, each rated at 80 hp., were recently installed in the basement of a new addition to a building in Chattanooga, Tenn. The settings were of the steel-cased type, and the boilers were set entirely independent of each other.

Boiler No. 2 was fired up, and after the setting had time to get hot, an explosion occurred, supposedly in the setting. Very little apparent damage was done. The fire-doors were blown open, the rear soot door blown out of position, the ashpit torn up to a depth of 2 or 3 in. and the grates disarranged. No careful examination was made, as the attendants supposed the explosion was the result of the sudden ignition of a collection of gas in the furnace. As the fire had been started merely for the purpose of drying out the setting, it was not restarted.

On the following day, the damper and draft doors of boiler No. 1 were opened and the setting carefully examined to prevent a recurrence of the accident of the day previous. A fire was then started under this boiler, and after the setting had become hot and ashes and hot coals had deposited in the ashpit in sufficient quantity to thoroughly heat it, an explosion occurred similar to the one that had occurred under boiler No. 2, but of more serious moment. The fire-doors were blown open, rear soot door blown out of position, ashpit torn up to a depth of 6 or 8 in., and the grates were hurled up against the boiler and fell down in disorder into the ashpit.

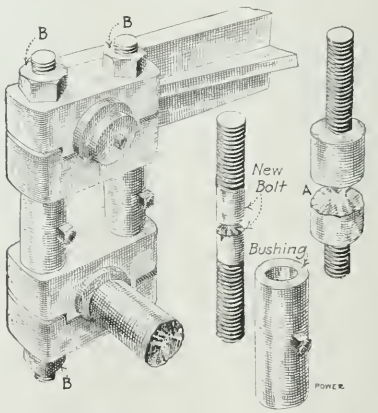
A boiler inspector was notified of the explosions and hastened t the scene. He proceded immediately to make a thorough examination, and found that the explosions were not from gas in the furnaces, but that they had occurred under the ashpit, the bottoms of which were formed by the concrete floor of the basement. The conclusion was that the steam had been generated from the excessively damp soil under the concrete, or from water that had soaked through cracks or apertures which had been closed by the expansion of the concrete as it became hot, and there was left no avenue of escape for the steam. As water had stood in the basement, both before and after the concrete floor had been put in, the conclusion was logical, and at once accepted by all concerned.

D. A. Simpson.

Chattanooga, Tenn.

Repairs to Link of Pump

A bolt broke on one of our air pumps, and caused a shutdown during time the repairs were being made. The bolt was of peculiar construction, as shown at *A*, and



Showing New and Old Bolts for Link

to remove it we had to disconnect the pump. It was the first of its kind to be broken, and none were in stock.

We made an improvised bolt with a piece of pipe and started the pump. We made new bolts, but of a different design than those furnished by the pump makers. The old bolts *A* were in one piece, large in the middle to provide shoulders on which the bottoms of the bearing caps could rest while the nuts *BBB* were tightened. The construction of these old bolts made it necessary to take the link apart when a bolt broke.

To avoid doing this the new bolts were made of the same diameter throughout their entire length and a sleeve, made f a piece of pipe through which the bolt was inserted, provided the necessary shoulders.

Fall River, Mass. Robert Colbert

QUESTIONS BEFORE THE HOUSE

Rubbish as Fuel

In the issue of May 27, there appeared on Page 745 an editorial on burning of waste materials where coal was the principal fuel. On the other hand, I have burned thousands of cords of waste material where the latter constituted the main fuel, and where coal was advantageously used for improving the combustion of the waste material. For this purpose a few shovelfuls of coal spread over the fire and worked below the bed of waste fuel have proved very satisfactory in preventing fine material like sawdust from falling through the grates and in ventilating the bed of fuel. Quite large lumps of coal may be used; in fact, old firebrick or large clinkers from the ash pile can be used in the same way to good advantage.

In my opinion the old-style straight grates with ⅜- to ½-in. openings and a layer of clinker spread over the grates to keep the waste fuel from falling through are far better than any of the special designs of grates for burning sawdust that have come under my notice. Sawdust laid on a bare grate makes too close a bed for obtaining a good draft and will only burn from the ventilated surface inward. It therefore needs to be broken up to expose as large a surface to draft as possible, but the bed should not be disturbed any oftener than necessary or the fire becomes smothered. All the cleaning that is necessary is to take a single-pronged hook laid flat on the grates and rake it back and forth a few times during the run. After cleaning a sawdust fire in this manner the heated clinker or lumps of coal will cause the bed of fuel to be quickly ignited and for the same reason that combustion of a sawdust fire is always active next to the hot walls of the furnace.

V. L. Ballou.

North Adams, Mass.

Water-Column Blowoff Piping

In the June 3 issue appears an editorial note attached to the article of Edward T. Binns, a part of which reads, "It is hardly to be recommended that the column blowoff be piped elsewhere than to the ashpit."

I wish to take exception to this statement. It is true that it is common practice to run a ½-in. pipe from the column to the ashpit, to be used as a column blowoff, but this is not good practice, for several reasons: First, the function of this blowoff is to keep the lower connection from the boiler to the column free from sediment. With a small pipe this cannot be effectually done as the amount of water passing through the small pipe is not sufficient to move the water in the larger pipe (which is usually 1¼ in.) fast enough to thoroughly clean it.

My practice is to make the column blowoff equal in size with the lower connection and to connect it around into the boiler blowoff pipe. In this way a full 1¼-in. opening can be had, and things have got to move when the valve is opened. My method of column blowoff connections meets with the hearty approval of all boiler inspectors who visit the plant.

There are other minor reasons why this blowoff pipe should be kept out of the ashpit, such as the possibility of accidents such as happened to Mr. Binns; the deterioration of the bridge-wall caused by the blowing of steam and hot water forcibly against it, etc.

E. H. Roberts.

East Norwalk, Conn.

Engine-Cylinder Lubrication

In reading the article on the above subject by Willis Lawrence in the May 10 issue of Power, I was deeply interested in noting the beneficial effect of the graphite in the oil. It would be of interest to know what amounts of graphite were found to be sufficient to take the place of the varying per cents. of animal fats, and whether the same methods of lubrication can be used for feeding graphite and oil as is used for cylinder oil alone.

The subject is of such vital nature and so little definite information is at hand that the publication of such articles as "Engine-Cylinder Lubrication," as well as discussion should be of great value to engineers.

John W. Hacker.

Gary, Ind.

Ammonia and Water for Hot Bearings

I have just read the article in the Apr. 1 issue of Power relative to the use of ammonia for cooling hot bearings. While I have never expanded liquid ammonia directly into the bearings, I have expanded it into a 5-gal. can of lubricating oil until we had nothing but a lather which was remarkable for its cooling properties, and which fed very fast through the gravity-type oiling system. This lather cools the bearing very quickly. The bearings were 9½ in. in diameter by 9½ in. wide, of solid bronze, and they were chronic "heaters." Cooling them with this lather enabled us, in three instances, to operate until Sunday morning, when repairs could better be made. No ill effects were noticed from the use of the ammonia.

To show that it takes considerable time for ammonia to attack bronze and brass, the following experience serves well: Two brass valves and a brass union were placed in a liquid-ammonia line, the intention being to use them for a day or two until regular ammonia fittings could be procured. But it was three months before they were removed, and the valves and unions were then as good as new, being much cleaner inside than when first installed.

I should not fear the effects of ammonia for such few times as it may be applied to bronze bearings. And, as for babbitt, ammonia will never harm it. As for applying water on a babbitted bearing that is running fairly well, do not do it. The result is generally a slight roughing of the surface, forming little waves in the oilways,

which become filled with black flakes. Use plenty of water and oil on bronze bearings as a polished surface and a cool-running bearing result, but keep water off the babbitted boxes. The above has been my experience in rolling-mill and blast-furnace work.

D. L. Fagnan.

Amarillo, Tex.

How Did It Happen?

Replying to F. A. Hunter's inquiry, page 426, Mar. 25 issue, as to how it happened that the exhaust valves of his Corliss engine became turned upside down, if the valves had originally been put in right side up, then with the reach rod unhooked it is possible that the lengths of valve rods and valve arms are such that by moving the wristplate far enough the valve arms could have become turned upside down, thus turning the valves bottom side up. Mr. Hunter should take diagrams to determine whether the exhaust valves are working right by merely turning them right side up or whether the valve arms became turned upside down, thus causing the valves to be turned bottom side up. In this manner he may come to a conclusion of how it happened that the valves were found to be upside down.

Theodore C. Robinson.

Fort Madison, Iowa.

Centrifugal Pumps for Boiler Feeding

In these columns there has recently been some discussion on the use of centrifugal pumps for boiler feeding. It might be of interest to some of the readers of Power to know that on a certain ship, running regularly on the Pacific Coast, there are in use two centrifugal pumps, 2½-in., four-stage, direct-driven by steam turbines. These pumps feed boilers 16 ft. in diameter by 11½ ft. long, working under 200 lb. pressure. The supply is taken from a filter box under a 5½-ft. head, the hotwell temperature being 110 deg. F. The steam to the pumps is controlled by a chronometer valve and float which is located in one compartment of the filter box, and operates automatically with a lever connection between the float and the chronometer valve. The delivery from the pump is discharged into a filter of the cloth-covered type, thence to a closed heater and finally to the boilers.

These pumps run at 3000 r.p.m. and in addition to the float control, have a Pickering governor located at the turbine throttle. This, of course, would be brought into action and immediately shut off the steam, should anything happen to the float governor.

J. A. McVay.

San Francisco, Calif.

Experiments on Efficient Boiler Operation

In his article on this subject, page 799, June 3 issue, B. W. Rogowski says regarding the unavoidable losses in dry chimney gases:

"Assume the air supply to be theoretically correctly proportioned to the amount of coal burned, i.e., 11.5 lb. per pound of combustible; atmospheric temperature, 60 deg. F.; stack temperature at the base, 450 deg. F.; specific heat of the flue gases, 0.24. Then the heat carried away by the least possible weight of chimney gases with perfect combustion and conditions specified above would be

$$[(11.5 + 1) \times (450 - 60)] \times 0.24 = 1170 \text{ } B.t.u.$$

"With fuel having a calorific value of 12,500 B.t.u. per pound this means an unavoidable loss of

$$\frac{1170}{12{,}500} \times 100 = 9.36 \text{ } per\ cent.$$"

His figure—9.36 per cent.—is incorrect, for after obtaining 1170 B.t.u. as the loss per pound of *combustible* he should have divided by the heating value of a pound of combustible, which with the fuel considered, would be about 14,500 B.t.u. This gives

$$\frac{1170}{14{,}500} \times 100 = 8.07 \text{ } per\ cent.$$

Charles C. Cobb, Jr.

Kewanee, Ill.

Electric Elevator Question and Answers

In the June 10 issue, Mr. Pyatt, in criticizing my article under the above heading, states that in his experience the car operates the limit switch. This may be true in his individual plant, but if he has seen elevator equipment in many plants he will agree with my statement that when the car is down below the bottom floor the counterweights are up at the top where there are two limit switches, one for the car when it is at the top and one for the counterweights when the car is at the bottom; both switches will break the circuit and stop the motor.

Mr. Pyatt claims that by holding the potential switch in place the car may be moved quicker. He neglects to state that with most electric elevators this will require an extra man to hold down the clapper switch on the back of the brake band. As a matter of fact, neither of these methods is the quickest. By simply putting a piece of ½-in. iron under the brake spring and raising the brake-band weight arm, the car will rise unaided if the load is off. He does not see why an elevator should make a sudden stop on the up stroke and not on the down stroke. If he will study the illustration accompanying my article "Care of Electric Elevator Brakes," Power, Oct. 8, 1912, page 539, he will be enlightened. I often wondered why this is so, but after working on several brake connections I find that it requires a certain tension on each of the brake bands to get a good, easy stop, both on the up and down motion. There are 16 elevators in our plant, so we get plenty of experience.

Mr. Pyatt does not see how the safeties can be loosened without pulling out the governors. Here is where experience and actual familiarity with the machinery under one's care counts for much. All that is necessary is to raise the car about a foot with the spanner wrenches and the governor ropes will be very slack and will allow the spool under the car to be turned off. It is not necessary to pull out the governor until the safeties are out. Mr. Pyatt further states: "When the centrifugal governor trips (which it can only do when the car is on the down trip), etc." If he will visit a few plants he will, no doubt, see electric elevator governors that operate both on the up and down trips.

A. C. Waldron.

Revere, Mass.

INQUIRIES OF GENERAL INTEREST

Pump Lift Through Different Sized Pipes—When two steam pumps of the same design and size are working with 100-lb. steam pressure, one having a 3-in. discharge pipe and the other a 6-in. discharge pipe which pump will force water to the greater height?

A. S.

The pumps would force water to the same height, but the pump having a 6-in. discharge would work faster and would pump more water in a given time. The pressure exerted by the water piston would be the same in each case and without friction there would be only the same velocity of discharge, and the 6-in. pipe having four times the cross-sectional area of the 3-in. pipe, the latter would discharge only one-quarter as much as the former in a given time. When friction is considered it is to be seen that the 3-in. pipe would discharge less than one-quarter as fast, because a larger proportion of the initial pressure would be lost in pipe friction, leaving less pressure available for production of velocity.

Boiler Evaporation—How many pounds of water can be evaporated from one pound of coal of a heat value of 12,238 B.t.u. per lb. in a boiler having an efficiency of 85 per cent.?

P. J.

The heat units effective in evaporating water will be

$$12{,}238 \times 0.85 = 10{,}402.3 \text{ B.t.u.}$$

The weight of water evaporated per pound of coal would depend upon the feed-water temperature and the boiler pressure. These conditions are not stated. Whatever the conditions the equivalent evaporation, i.e., from and at 212 deg. F. and atmospheric pressure, will be

$$\frac{10{,}402.3}{970.4} = 10.72 \text{ lb.}$$

For any other conditions this figure should be divided by the factor of evaporation applying. For instance, with a feed-water temperature of 200 deg. F. and a boiler pressure of 100-lb. gage, the factor of evaporation would be (from tables in engineers' pocketbooks) 1.052 and the actual evaporation

$$\frac{10.72}{1.052} = 10.19 \text{ lb.}$$

per pound of coal.

Indicating Through Drip Cocks—To find the indicated horsepower of a slide-valve engine, which is not tapped for an indicator, can I connect the indicator piping to the cylinder-drip connections and get fairly accurate results?

H. W. C.

While this is not to be recommended as regular practice and is discouraged by instrument makers, it can be done under necessity, but certain precautions must be taken to get reasonably accurate diagrams. Quoting from "Inaccuracies of Indicators," by James G. Stewart ("Power," June 17, 1913, page 851), "A chief source of error is the presence of water in the indicator or in its connection with the cylinder." The connection, therefore, must be free of water when the diagram is taken. The indicator piping should be attached to a tee inserted between the cylinder and the drip valve. No diagrams should be taken until the cylinder is thoroughly warmed up and the engine is being suplied with dry steam. Then the diagram should be taken immediately after bleeding the cylinder of water.

Steam Saved by Cutting Off—How much less steam at 93-lb. pressure (gage) would be used by cutting off at 11 in. instead of following full stroke in a cylinder 16 in. long by 12 in. diameter?

R. S.

The cross-sectional area of a 12-in. diameter cylinder is 113.1 sq.in. Neglecting the space occupied by the piston rod the volume is

$$113.1 \times 16 = 1809.6 \text{ cu.in.}$$

Cutting off at 11 in. of the stroke, the volume of steam would be

$$113.1 \times 11 = 1244.1 \text{ cu.in.}$$

The difference of volume of steam following full stroke and cutting off at 11 in. of the stroke, therefore, would be

$$1809.6 - 1244.1 = 565.5 \text{ cu.in.,}$$

or

$$\frac{565.5}{1728} = 0.327 \text{ cu.ft.}$$

Steam at 93 lb. per sq.in. boiler pressure is at

$$93 + 14.7 = 107.7 \text{ lb. absolute.}$$

From steam tables we obtain 0.2423 lb. as the weight of 1 cu.ft. of steam at 107.7 lb. absolute, so that the weight of steam used would be

$$0.2423 \times 0.327 \text{ cu.ft.} = 0.0792 \text{ lb.}$$

less per stroke when cutting off at 11 in.

Loss from Uncovered Steam Pipe—What would be the loss per year, due to radiation, per square foot of uncovered steam pipe, carrying steam at 120 lb. pressure, absolute, when the temperature of the air is 60 deg. F. and the coal has a heat value of 14,125 Bt.u. per lb. and costs $1.25 per ton?

W. A. R.

Each square foot of pipe surface would radiate about 2½ B.t.u. per hour per degree difference of temperature between the steam and air. Steam at 120 lb. absolute has a temperature of 341.3 deg. F. The air temperature being 60 deg., the difference is

$$341.3 - 60 = 281.3 \text{ deg. F.}$$

and the radiation per hour

$$281.3 \times 2.5 = 703.25 \text{ B.t.u.}$$

Per year then it would be

$$703.25 \times 24 \times 365 = 6{,}160{,}470 \text{ B.t.u.}$$

The coal required would depend upon the efficiency of the boiler. Assuming 70 per cent., for average fair conditions, and the heat utilized per pound of coal would be

$$14{,}125 \times 0.70 = 9887.5 \text{ B.t.u.}$$

Then the coal equivalent of the heat lost through the pipe is

$$\frac{6{,}160{,}470}{9887.5} = 623.056 \text{ lb.}$$

or

$$\frac{623.056}{2000} = 0.3115 \text{ tons}$$

and its cost

$$0.3115 \times \$1.25 = \$0.389 \text{ or } 38.9\text{c.}$$

per square foot.

Horsepower to Accelerate Hoisting Drum—If the face of a hoisting drum weighs 8000 lb., what will be the horsepower required to bring the speed of the rope winding on this drum from 0 to 1000 ft. per min. in 5 sec.? The diameter of the drum is 10 ft. and the face width 6 ft. Neglect the weight of the arms, hub and rope.

L. C. M.

The center of gravity of the cross-section of the rim may be assumed to have the same velocity as the cables, i.e., to have a final speed of 1000 ft. per min. or

$$\frac{1000}{60} = 16.667 \text{ ft. per sec.}$$

The kinetic energy or number of foot-pounds of energy in the rim when it has attained this velocity is given by the formula

$$K = \tfrac{1}{2} Mv^2$$

in which

$$M = \text{Mass} = \frac{\text{Weight}}{g}$$

and as

$$g = \text{Acceleration of gravity} = 32.16$$

$$\text{Weight} = 8000 \text{ lb.}$$

and

$$v = 16.667 \text{ ft. per sec.}$$

then

$$K = \tfrac{1}{2} \times \frac{8000}{32.16} \times 16.667 \times 16.667 = 34{,}550.82 \text{ ft.-lb.}$$

With uniform expenditure of power during 5 sec. there would be uniform acceleration and an expenditure of

$$\frac{34{,}550.82}{5} = 6910.16 \text{ ft.-lb. per sec.}$$

or

$$\frac{6910.16}{550} = 12.56 \text{ hp.}$$

in bringing the speed up to 1000 ft. per min.

ENGINEERS' STUDY COURSE

Making a Flue-Gas Analysis—Part V

Solution for CO_2

The solution for the first pipette, to absorb the CO_2, is caustic potash (chemical name, potassium hydrate) dissolved in the proportion of one pound of caustic to $2\frac{1}{2}$ lb. ($2\frac{1}{2}$ pints) of water.

Perhaps the most convenient method is to mix up ½ lb. of the caustic at a time. A good way to do is to fill an ordinary one-quart milk bottle about five-eighths full of water and add half of the sticks in a one-pound package of caustic. If you have a pair of reasonably accurate small scales, you can weigh the bottle and then add the required $1\frac{1}{4}$ lb. of water, thus securing greater accuracy than guessing at five-eighths of a quart. A half pound of caustic will make a little more than enough solution for five loadings of the pipette. And one loading of the pipette is sufficient for about 325 analyses where the

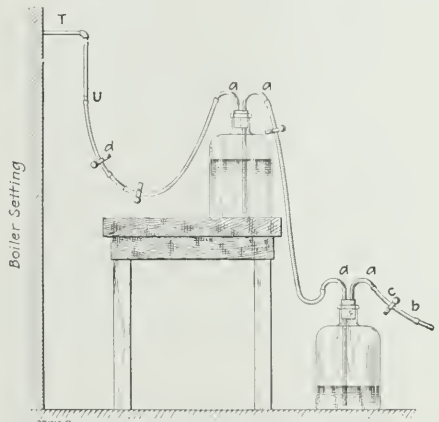


Fig. 5. Arrangement for Collecting a Time Gas Sample

percentage of CO_2 extracted each time is 12 per cent. Thus, one loading should last from three months to a year or more, depending on how often the apparatus is used. The bottle containing the unused part of the mixture should be carefully labeled, fitted with a cork or cover and stored away in a safe place. It is safest to handle the potash sticks with tongs rather than with the bare hands because while no harm will be done if both the sticks and your hands are dry, a disagreeable burn results if either happens to be moist. Use care in handling the solution when made up because a drop on the flesh will burn and a drop on clothing, shoes, etc., will eat a hole.

Solution for Oxygen

The solution for the second pipette, to absorb the oxygen, is potassium pyrogallate; made by mixing pyrogallic acid (which comes in the form of a powder) with a suitable quantity of the caustic-potash solution just described. As this solution absorbs oxygen it will quickly lose strength if exposed to the air; hence it must be sealed up as soon as possible.

A good way to mix the solution is to put 1 oz. of the pyrogallic acid into a quart bottle, pour in about a pint of the caustic solution and immediately seal the bottle air-tight.

After loading the pipette, place the gooseneck and rubber bag on the back leg as quickly as possible to exclude the air. One loading of the pipette will absorb about 200 c.c. of oxygen. Thus, if the average amount of oxygen in the flue gases analyzed is, say, 8 per cent., the solution would be good for about 25 analyses.

Solution for CO

The solution for the third pipette, to absorb the CO, is acid cuprous chloride. This can be most conveniently made as follows: Put enough copper oxide into a quart bottle to make a layer on the bottom ¼ in. thick. Put in ten or a dozen lengths of No. 10 gage copper wire, bare and clean, cut in lengths to reach from the top to the bottom of the bottle. Then, fill the bottle with hydrochloric acid (hydrochloric acid is simply equal parts water and muriatic acid). Seal the bottle air-tight and shake it occasionally to hasten the reaction. When the solution turns nearly colorless (after about 48 hr.) it is ready to use. After some of the solution has been taken out to load the pipette, immediately add more hydrochloric acid so as to keep the bottle full all the time. As the copper wire and copper oxide gradually disappear, add some of each from time to time so as to constantly keep about the usual amount in the bottle.

As this solution also deteriorates when exposed to the air, be sure to connect the rubber bag to the pipette as soon as it is loaded. One loading of the pipette will absorb about 100 c.c. of CO; hence it would be good for about 100 analyses where the amount of CO in the flue gas averaged 1 per cent.

When any of the solutions begin to show signs of weakness they should immediately be renewed regardless of the length of time they have been in use.

Taking the Sample

The best place from which to take the sample of flue gas is from the last pass, if the boiler is a water-tube, or from the connection between boiler and breeching if a fire-tube. Cut a length of ½-in. pipe *T*, Fig. 5, long enough to extend half way across the gas passage and project out about 6 in. at one side. Fit an elbow and vertical connection to this as shown. The pipe *T* may be inserted either through a drilled hole or through some existing opening. In either case, stop up the hole or opening around the pipe with waste or plastic asbestos so as to prevent the danger of air leaking in and spoiling the sample. Be sure that the piping is made up air-tight.

aw the end U down so that ¼-in. rubber tubing can pushed over it.

If instantaneous flue-gas readings are wanted, connect e Orsat and the end U by a length of rubber tubing and oceed to draw in the sample as before directed.

If a sample representing a certain period of operan is desired, an arrangement, such as shown in Fig. may be used. Obtain two large bottles, such as those which spring water is sold, and fit them with rubber rks, each perforated for two glass tubes. These corks n be secured from the dealer who sells you the flue-gas paratus. Then, fit each bottle with one long glass tube, d one short one in the manner shown. If the top of ch glass tube is heated and bent over, as shown at a, the bber tubing is not so likely to kink up and stop the w of water.

Fig. 6. Arrangement of Sampling Bottles and Apparatus

Fill one bottle full and the other about one-eighth full water. Connect the long tube of each bottle with a ngth of rubber tubing about 6 ft. long; connect each ort tube with a length of rubber tubing about 12 to 18 . long and in the end of these short lengths insert a ass-tube nipple, 4 to 6 in. long, as shown.

Arrange the bottles one above the other, as shown in g. 5, and let water siphon into the lower bottle until is full and water begins to run out at b. Then, set ach cock c and reverse the bottles, connecting b with e tubing d. Before doing this, however, apply the small nd pump, which comes with the flue-gas apparatus, to e end of the tubing d and expel all the air in the pipg; then, set a pinch cock on d as close to the lower end possible. If these directions are followed closely, very tle or no air will get into the system to make the samunfair.

Now, release all pinch cocks and allow the water to siphon from the upper to the lower bottle. This causes a vacuum in the upper bottle which draws in the gas from the boiler.

By heating the end of one of the long glass tubes and drawing it down to a finer opening, a longer time will be required to siphon the water over and hence to fill the upper bottle with gas. If, for instance, an 8-hr. sample is desired, a little experimenting with the size of opening in the glass tube will result in getting the time of water flow about correct. Of course, as it is not necessary to have more than perhaps a quarter of a bottle full of gas, the length of time required for the water to siphon over does not matter much, provided it is longer than the length of the test desired.

When the desired gas sample has been drawn into the upper bottle, set all pinch cocks and arrange the bottles, as shown in Fig. 6, the one full of water slightly higher than the other. With this arrangement the gas is under a slight pressure and if the system is accidentally opened, gas will escape, but no air will leak in to spoil the sample. Connect the gas bottle with the flue-gas apparatus, as shown, and proceed with the analysis as explained in previous paragraphs.

As water absorbs CO_2, the water in the collecting bottles should be saturated with gas before samples for testing are collected. This can be done by drawing some gas first into one bottle, then into the other and allowing it to stand for some time, shaking the bottles now and then to induce complete saturation.

Care of Apparatus

In course of time the rubber tubing and connections used with the Orsat will become hard and crack, when they will need renewing.

The caustic will affect the glass pipettes. Hence, if the apparatus is not to be used for some length of time, it is well to empty the apparatus before storing it away.

The glass stop cocks must be kept clean or they will not remain air-tight. Also, if they are not lubricated frequently, they may become stuck and cause trouble. A good lubricant to use is vaseline. This point should be attended to frequently if trouble is to be avoided.

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16 Lb. per Hp.-Hr. Noncondensing

On Apr. 9, 1913, F. W. Dean, of Boston, conducted a trial of one hour's duration on a Lentz simple horizontal noncondensing engine erected at the plant of the Erie City Iron Works for the purpose of testing with superheated steam. The engine drove an electric generator by means of a belt, and the current was absorbed by a water rheostat.

The exhaust steam was condensed at atmospheric pressure by passing it through four Erie feed-water heaters, through the coils of which cold water was run. This was done for the purpose of weighing the exhaust in barrels resting upon platform scales. The steam was so perfectly condensed that only a trifling quantity of vapor escaped, so small that it would not affect the result by a measurable quantity. It was found by examination that no water leaked into the exhaust from the condensing supply.

The revolutions of the engine were determined by a counter worked from the valve-gear. The indicator reducing motion was practically correct. The temperature

and pressure of the steam were taken from the steam chest of the cylinder, the former by a refined stem graduated thermometer and the latter by a test gage. The scales were carefully tested by means of standard weights and made correct.

The indicator diagrams were taken every 10 min. with a Crosby inside-spring indicator, and all other readings at the same intervals, except the water records. There were two weighing barrels and each was allowed to fill until the scale beam tipped, the other barrel being meanwhile emptied.

The test lasted one hour only, and the data were complete for that hour. It would have been longer if the generator had not begun to burn out toward the end of the second hour. Concerning the accuracy of a test of such short duration, as the engine was run for some time before the test began, it was properly heated, and the weight of condensed steam can be determined with the greatest accuracy in the manner described.

After the test was over the cylinder head was removed and the diameter of the cylinder and the stroke of the piston measured, with the following results: Diameter of cylinder, 19.167 in.; stroke of piston, 21 in.; diameter of piston rod, 4 in. The pressure, temperature and superheat of the steam were as follows:

Time, p.m.	Press., lb.	Temp., deg. F.	Superheat, deg. F.
1 : 50	135	420	61
2 : 00	133	444	87
2 : 10	133	460	103
2 : 20	134	456	98
2 : 30	133	456	99
2 : 40	131	456	100
2 : 50	132	458	101
Averages	133	450	92.7

The average temperature of the exhaust steam was 210.5 deg. F. The barometer was 29.59 in. The exhaust pressure absolute was about 16.2 lb., the temperature of which, if saturated, would be about 217 deg. As the temperature of the exhaust was below this it follows that no superheat was left in the steam when it entered the exhaust pipe.

RESULTS OF TEST
Spring 60

Average r.p.m.	Average Areas Head Card	Crank Card	Average Length Both Cards	Horsepower Head	Crank
206.18	2.464 sq.in.	2.448 sq.in.	3.66 in.	127.4	121.1

Total average horsepower 248.5
Steam used in hour, lb. 4008
Steam used per hp.-hr, lb. 16.13

During the portion of the second hour while the test lasted the superheat was about 119 deg., and the economy was about 16.03 lb. Assuming an initial pressure of 148 lb. abs., 92.7 deg. F. superheat, and exhaust at 217 deg., the Rankine efficiency at 16.13 lb. would be 91.5 per cent., and at 16.03 lb., and with the 119 deg. superheat, a little over 90 per cent. These results are remarkable and perhaps the best that have ever been obtained from a simple noncondensing engine. According to Mr. Dean the engine ran perfectly and the valve-gear left nothing to be desired.

⁂

The Lighting Rates Committee of the board of supervisors of San Francisco has recommended that the ordinance establishing rates for electric current for the next year shall embody a reduction in the rate for lighting in residences and apartment houses from eight cents a kilowatt-hour to six cents a kilowatt-hour. It is estimated that this would mean a reduction of $250,000 in revenue to electric companies of the city based on the business of the present year. The Committee also recommends a reduction in the minimum charge for electric current from $1 to 75 cents a month. In addition the committee has reported that the present gas rate of 75 cents a thousand cubic feet should remain in force.—"Electrical Review & Western Electrician."

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

How would you like a big high one just this very minute? You know, when the light is flashing out all those rays of beautiful amber tint, and the creamy foam is billowed lovingly on the crest of the glass, and tiny diamond-like beads cling to its sides, and your shirt collar is thrown back, and your old carpet slippers dangle on one toe, and the willow rocker just fits, and the pipe draws right and the thermometer is climbing up in the nineties, and—

Say, son, there's nothing more satisfying to a 200-hp. thirst than a glass of good ice-cooled sarsaparilla—unless it's what you thought we meant when we first started this.

⁂

Seats in the New York Stock Exchange have shrunk over sixty millions, remarks "Collier's Weekly," and the common people have got Wall Street's goat. Give a sturdy gentleman goat half a chance, and most any seat will shrink; he plays the game where all the butting in is kept to himself. Everything seems to be shrinking these days, even the weather. Why not seats?

⁂

A Welsh coal king's daughter has been arrested as a militant firebug. Looks like girlie got the wrong slant on what constitutes a proper product of combustion.

⁂

Wilbur Smith, over to Alton, Ill., tips us off to a St. Louis furniture concern's method of mingling education with business. "For $1 down and $1 a month, a man can buy a bookcase filled with choice books; the books are thrown in." Wilbur says this scheme may help every engineer to a library without the bother of selection. Says he: "Who can select it better than his furniture man? Just send him the color of your carpet and the wallpaper, and he does the rest."

⁂

In an endeavor to help "the poor begrimed engineer" in his struggle with the examiners, John S. Myers gives this list of Q's and A's. They may cheer us up, whatever else they might do:

Q. Of what use is a steam dome on a boiler? A. To catch the steam.

Q. Of what use is a mud drum on a boiler? A. To catch the mud. (Don't mix my answers to the last two questions.)

Q. What precautions should the engineer take when necessary to stop, with heavy fires? A. If he was firing with natural gas the proper thing would be to shut off the gas, if firing with the usual fuels he should take the usual precautions.

Q. When should a boiler be blown out? A. When you don't need the steam for other purposes.

Q. When laying up a boiler, what should be done? A. "Laying up" is against the laws of gravitation. Don't try it; it can't be did.

Q. How do you find the horsepower of an engine? A. It is usually found about as specified and guaranteed, it is sometimes marked on the nameplate, the builders will usually answer a polite inquiry or, if you hanker after personal investigation, use an indicator, a planimeter and a slide rule and figure it out. This is the scientific P L A N. If not satisfied then, see how big a load it will pull.

Q. How much wood equals one ton of soft coal for steam purposes? A. That depends upon the wood and the fireman.

Q. What is vacuum? A. Nothing much, I don't guess.

Q. What is meant by triple-expansion engine? A. Something like a three bagger, only different. The batter goes three-quarter ways round on one hit while the steam gets three hits and makes three home runs.

Q. Is there any danger of a well fitted and tightly keyed flywheel coming loose? A. Lord protect us if there is! There's enough danger from the other variety.

Q. Where is the dead center of an engine? The point of stroke where the oiler cusses like a pirate when the engine stops there.

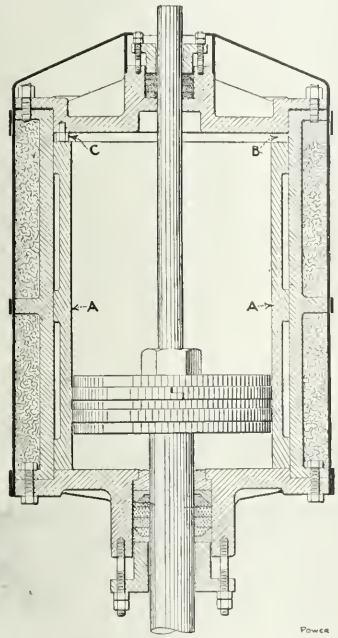
Q. Can you explain the term clearance? A. I can, but I've run out of paper; besides, you only asked me could I? Believe me! I can do it. If you really want to know what clearance is, come around to the power house some day and I'll tell you.

Loose Liner in Cylinder Causes Severe Knock

By Herbert E. Collins

While serving as refrigerating engineer aboard the ard Line S.S. "Mexico," an interesting breakdown of e of the main engines occurred. The ship was pro-lled by two triple-expansion engines and the 28-in. ameter high-pressure cylinder of the port engine was e seat of the trouble. The cylinder was constructed, as own in the sketch, with a liner *A*, which formed the ll of the cylinder. A tail rod extended through a stuff-g-box in the cylinder head.

An elusive knock developed in this cylinder which was ought to be caused by a shoulder on the tail rod at the



Engine Cylinder, Showing Liner That Worked Loose

d of its downward travel. This shoulder was dressed wn with an oil stone, but as soon as the engine became rm on leaving port, the knock returned. Many pos-ble explanations as to its cause were offered.

On the voyage in question, on the morning of the third ay out of New York, the knock had increased until it unded like the blows of a trip hammer and became uder and louder. The engineer on watch was standing ear the throttle lever when suddenly the sound ceased together and comparative silence ensued for a few revo-tions. This startled the engineer into releasing the amp on the throttle lever and he was still standing with e lever in his hand when the knock returned with a ash that could be heard in every part of the ship. The gine was immediately shut down, and we proceeded ith the starboard engine, while the high-pressure cylin-er head of the port engine was removed, and the cause of the trouble became apparent. The lining of the cylinder had worked loose, it having been merely forced into place and not secured in any way. It was this liner gradually becoming looser and looser and being raised by the piston on its upward stroke and then slammed down against the cylinder bottom which caused the increasing knock. There was a space of 5/8 in. between the top of the liner and the bottom of the counter bore in the cylinder head, as shown at *B*. This gradual loosening went on until the liner became adrift altogether and raising with the piston it jammed at the top of its travel for a few revolutions, causing the cessation of the knock, after which it proceeded to move with the piston once more, and to slam alternately against the cylinder head and the bottom of the cylinder.

The first assistant engineer made the repair in a very simple and effective manner. Four holes were drilled in the plug of the cylinder head near its circumference and tapped for 3/4-in. bolts. In the meantime bolts were threaded clear to their heads and when they were screwed into the holes the depth of their heads was found to equal the space *B*, as shown at *C*, and upon the head being replaced, and the engine started, the repair was found to be satisfactory. Although the liner was firmly secured in its place on our arrival at New York, it was not at all necessary, as the temporary repair would have done as a permanent one.

Power Costs at Worcester Consolidated Plant

In connection with a report on operating conditions upon the Worcester Consolidated Street Railway, data are presented on the cost of power production at the company's generating plant at Millbury. This plant, states the *Electric Railway Journal,* is the most modern street-railway generating station in central Massachusetts and at present contains four Edgeworth 820-hp. boilers with Murphy stokers, two 300-kw., 600-volt, direct-current generators driven by horizontal compound-condensing engines, and a 5000-kw. steam-turbo unit, supplying the Worcester system through step-up transformers and two 13,000-volt lines carried on steel towers to a 3000-kw. substation at Madison Square, Worcester, 6.5 miles distant. The operating steam pressure is 185 lb. The cost of operation taken from the station log on Feb. 18, 1913, was as follows:

Labor:	
Two machinists	$5.00
Three engineers	14.30
Three laborers	6.00
Three helpers	12.00
Six firemen	12.00
Three water venders	6.75
Three coal laborers	5.25
Total labor cost	$53.80
Total cost of fuel and supplies	337.72
Total cost of manufacture	$391.52
Total cost of manufacture per kw.-hr.	0.67
Kw.-hr. output	57,448

It is proposed that the water brought to Madrid, Spain, by the Isabel II Canal be utilized for the production of electricity. It is estimated that 3000 hp. can be developed and sold, and the receipts used to reduce the price of water to the ultimate consumer. It is thought that five or six years will be required to complete the Puenteviejas waterworks. When this is finished the two plants will have a storage capacity of 2,155,000,000 cu.ft. and a minimum of 9000 hp. can be developed.

Lanz Counterflow Superheater

By Dr. Alfred Gradenwitz

The new Lanz counterflow superheater, with bypass flue, has been designed to utilize the heat in the flue gases as much as possible by using the counterflow principle. Closed loops are avoided in arranging the serpentines, as the superheater coils are called, thus avoiding water pockets, and at the same time not interfering with the ready access to the smoke tubes and tightening screws of the tube system. Means are provided for quickly mounting and dismounting the superheater, throwing

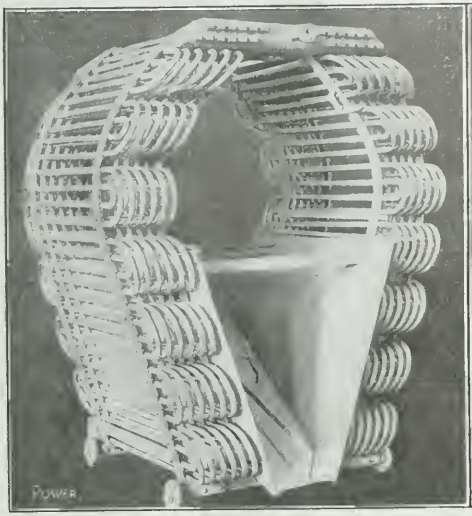


Fig. 1. Horseshoe Superheater for Large-Size Portable Steam Engine

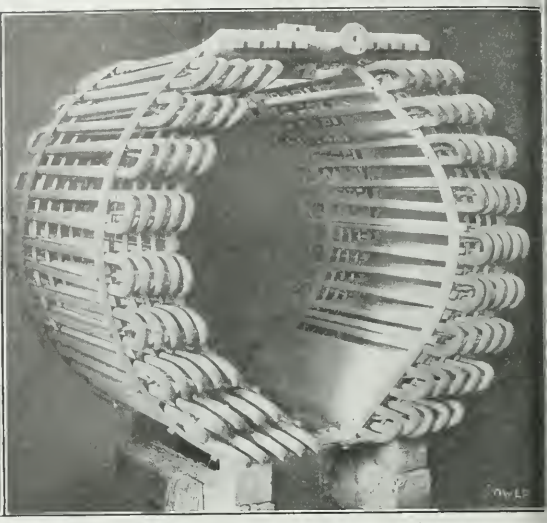


Fig. 2. Round Superheater for Small- or Medium-Size Portable Steam Engine

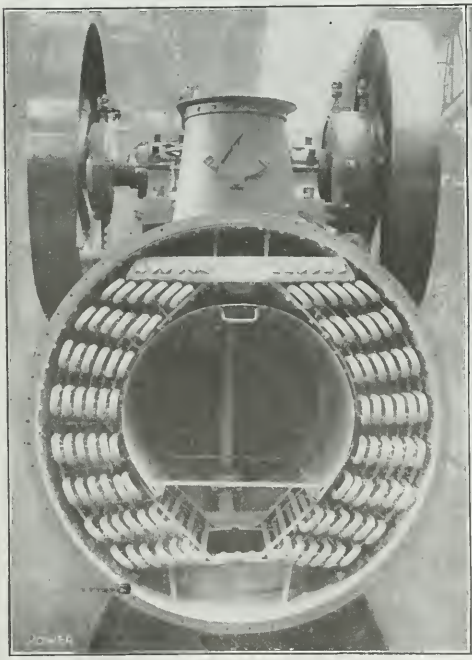


Fig. 3. Round Type of Superheater in Position

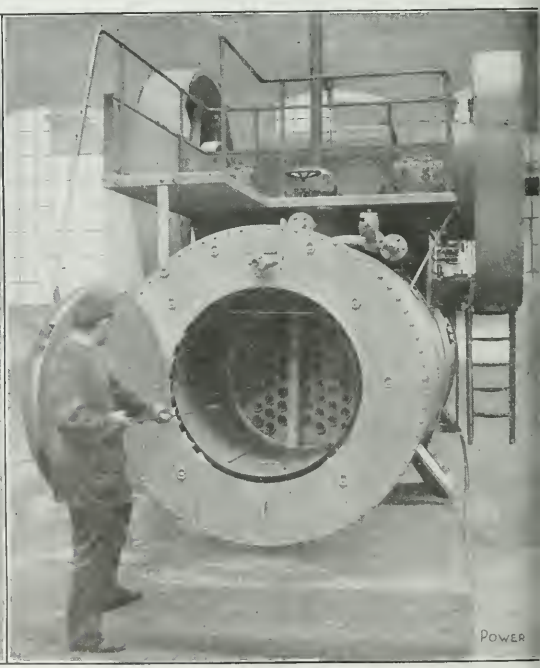


Fig. 4. Horseshoe Type of Superheater in Position

out of operation whenever desired, and controlling at ill the degree of superheat.

This superheater comprises a double-section annular asket of parallel horizontal serpentines which terminate the top and bottom in a wrought-iron steam-collector ibe. A removable drum locks the superheater against ne interior of the smoke box, and compels the furnace ases to follow a given course.

In the case of portable steam engines, having sheet-etal chimneys fitted on the smoke box, the flue gases om the boiler tubes go in a downward direction, and fter dividing to the left and right, encompass the super-eater serpentines in an upward direction, and escape the stack. The steam from the boiler enters the top f the superheater, and traversing the serpentines in a ownward direction, passes as superheated steam from he lower collector tube into the high-pressure cylinder. The steam and hot gases are thus directed in a counter-low, which insures high thermal efficiency.

In medium- and large-sized portable steam engines, the ue gases, after leaving the superheater, are led down-ard into a smoke channel and thence to the chimney. n this case the position of the drum is inverted and the moke gases are at first directed upward, so as to flow ound the superheater serpentines in a downward direc-ion. The steam enters the superheater from the bot-om, and passes from the top to the engine, so that the ounterflow principle is maintained.

The superheaters are made in two types of high-grade rawn-steel tubes. Small- and medium-sized portable team engines are provided with round superheaters, Fig. , fitted into the circular smoke box. In the case of arge-size steam engines a horseshoe-shaped type of uperheater, Fig. 2, is used, which at its lower end pene-rates into a masonry extension of the smoke box, resting n rollers and rails. The drum in this case is made of everal sections, thus facilitating its removal. Figs. 3 nd 4 illustrate the round and horseshoe types of super-eaters in position.

The most striking advantage of the superheater is the atented arrangement of the superheater tubes, which ise continually in horizontal serpentines, without form-ng water pockets, thus eliminating any risk of water-ammers. The precipitated water of the superheater ows by gravity to the lower steam-collector tube, to be ischarged through a cock.

In the case of large-size superheaters the lower part s specially designed as a collector for the flue dust which, liding on an inclined plane down to a discharge door, s readily discharged during operation. This inclined lane comprises a valve actuated from outside, by means f which part or all of the flue gases can be directed im-ediately into the chimney or the smoke channel, thus llowing the superheater during operation to be wholly r partly cut out, and the degree of superheat controlled t will.

The superheater is cleaned by a steam-jet blower, the oot being discharged from the bottom through the dis-harge door, or in the case of the round type of super-eater, through a door in the smoke-box bottom.

The superheater is easily removed, after loosening two anges and the smoke-box bottom, by withdrawing it end-ise through the front of the smoke-box and all parts re thus made readily accessible.

Welding Locomotive Boiler Tubes

At the annual convention of the American Railway Master Mechanics' Association, held in Atlantic City on June 11 to 13, the committee on Designs, Construction and Inspection of Locomotive Boilers presented an interesting report dealing mostly with the maintenance of locomotive boilers. The committee had been instructed to investigate the results obtained by electric welding and it also included results obtained by the oxyacetylene process. Extracts from the report follow:

A road using the oxyacetylene process welded in a number of small tubes and omitted copper ferrules, as with them they could not make satisfactory welds. The tube sheet was prepared, as shown in Fig. 1. View *A* shows a tube projecting through the sheet far enough so that when finished the beads will be the same size as when beaded in the regular manner. View *B* shows the tube after being welded. The same road also experimented with flues welded, as shown in Fig. 2. The tubes were allowed to extend through the sheet $\frac{3}{16}$ in., as at *A*, and were prossered and then welded as at *B*, after which a

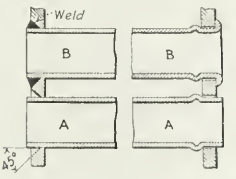


Fig. 1

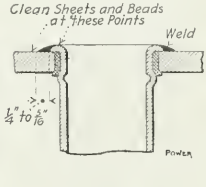


Fig. 2 Fig. 3

beading tool was used to smooth up the head. These flues have been in service only a short time but so far have been satisfactory.

Another road using the oxyacetylene process for welding believes that the copper ferrules are not necessary. The flue sheet is prepared as follows: The old flue having been removed, the first operation is to draw the centers of the back and front flue sheets toward each other. The center of the back sheet is drawn forward about $1\frac{3}{4}$ in. and the front sheet about $1\frac{1}{2}$ in. This is accomplished by applying 11 stay-rods distributed in a circle about $2\frac{1}{2}$ ft. in diameter, one of the rods being located in the center. While these rods are under tension the back flue sheet is annealed around the edges by an oil torch. The rods are then removed and there is a permanent dish in the back sheet of about $1\frac{1}{4}$ in., and in the front sheet of $1\frac{1}{8}$ in. The holes are then countersunk on the fire side to a depth of $\frac{1}{4}$ in. The flues are set in place projecting $\frac{1}{8}$ in. beyond the flue sheet, and are then rolled and welded.

One road had considerable difficulty with the large superheater tubes in the back flue sheet. One engine which had a flue mileage of 75,000 was brought to the shop and the large flues welded electrically. Nothing was done to the flues or beads except to clean them before welding. These flues were originally provided with copper ferrules. Metal was built around the head as shown in Fig. 3, and the weld was made from the edge of the bead to the sheet. The reason that the ferrules and flues were prossered and rolled was that the welding was more in the nature of an experiment and proved so successful that the method was continued. The engine was placed

in service and has made 14,000 miles without giving any flue trouble.

From the reports received from different roads it was apparent that considerable difficulty is experienced in welding flues by the oxyacetylene process, while with the electric process satisfactory results are obtained. One road especially tried out both methods and has adopted the electric process for standard practice.

From cost figures given in the report it was shown that the cost of welding flues electrically is cheaper than by the oxyacetylene process. The cost per flue is increased if the weld is made after the flues are set in the regular manner, but the maintenance cost is almost entirely eliminated and the engines can be kept in service a greater length of time. Present indications are that the flues can be run the three-year limit without removal.

Bristol's Float-Type Recording Differential-Pressure Gage

This new float-type differential recorder, Fig. 1, has been tested out under practical operating conditions. It was invented and developed by Prof. W. H. Bristol and is manufactured by the Bristol Co., Waterbury, Conn., to meet requirements for which the spring-pressure types of differential recorders are not suitable, that is for very low ranges of differential pressure in air, gases, liquids or steam, for applications where the static and differential pressures fluctuate rapidly, and also to satisfy the demand for instruments to record the rate of flow or volume directly on charts having uniform graduations in units of flow or volume.

The construction and principle of operation of the instrument will be understood by referring to the sectional diagram, Fig. 2. There are two pressure chambers *A* and

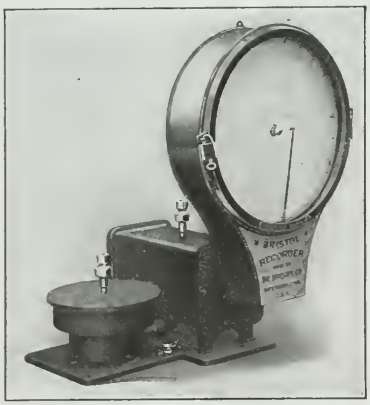


Fig. 1. Float-Type Recording Differential-Pressure Gage

B intercommunicating through the connection *C*. A cylindrical float *D* is located in the pressure casing *A*, and is connected by arms to the shaft *F*, which extends through the casing, and to which the recording arm *G* is directly connected.

Connection is made by the pipes *H* and *I* between the pressure chamber *A* and *B* and the two pressures the difference of which is to be recorded. Mercury or water is employed in the pressure chambers, according to whether the differential range to be recorded is high or low. When the higher pressure is applied to the chamber *B* through the pipe *I*, the level of the liquid in this chamber is lowered and that in the float chamber is raised, carrying the float and the attached recorder arm with it, thus making a record on a circular chart as it is revolved by a special clock at the desired speed.

By making the cross-sections of the pressure chamber *B*

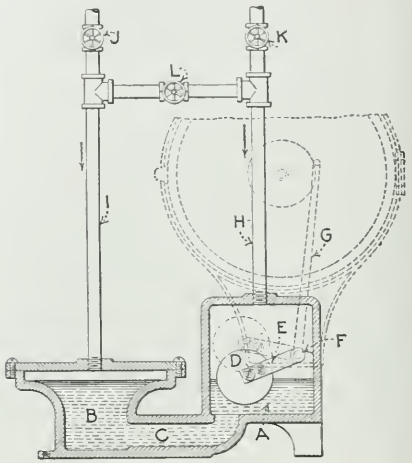


Fig. 2. Section through Gage

of certain proportions, it is possible to produce a scale whose graduations are uniform for equal increments of flow or volume. The Bristol-Durand radii-averaging instrument can, therefore, be used to obtain a total flow or volume from the chart record of this instrument for a period of 24 hr.

As these gages will operate on extremely low differential ranges they are particularly well adapted for use in connection with Pitot tubes for recording volumes of liquids, air or gases.

The chart used is graduated in thousands of cubic feet of gas per hour, the range being from 0 to 500,000 cu.ft. per hr. The working part of the chart above 150,000 is provided with uniform volume graduations.

This instrument may be used to record the head of water in tanks under varying pressure, as, for instance, height of water in steam boilers and heaters. Another special application is that of recording the flow of water through a notch or over a weir, even though the liquid is under pressure or a vacuum.

In the United States steam-railroad electrification is now in operation or in course of construction on 1645.3 miles of single track, and about 1250 miles in addition have been approved for electrification. The first such work was done by the Baltimore & Ohio at Baltimore in 1895. The greatest mileage of the 1645.3 miles owned by any one railroad is that of the New York, New Haven & Hartford, 594.8 miles, of which 104.4 miles is or will be operated by low-voltage direct current, and 490.4 by high-voltage single-phase. The New York Central and the Pennsylvania systems each contribute about 400 miles to the total, using the low-voltage direct-current system. The Butte, Anaconda & Pacific and the Southern Pacific each have about 90 miles under high-voltage direct current.

Pennsylvania N. A. S. E. Convention

The 14th annual convention of the Pennsylvania State Association of the National Association of Stationary Engineers opened at Chester, Penn., on June 27, in the main auditorium of the Young Men's Christian Association building. It was about 11 o'clock when the session was called to order by N. D. Orms, the president, of Johnstown. About 50 delegates were present.

The address of welcome was made by Mayor William Ward, Jr., who assured the visitors that Chester extended the glad hand of hospitality to them and felt honored by their presence. He expressed the hope that they would fully enjoy themselves during their two days' stay in the oldest town in the Keystone State.

The response was made by Samuel B. Forse, treasurer of the state association. Remarks were also made by Albert N. Monsinger, the secretary, and A. C. Cotton, the vice-president.

A musical and literary entertainment was given in the auditorium under the auspices of the local reception committee, composed of James D. Rostron, chairman; Fred D. James, secretary; Ernest Uff, treasurer; Charles C. Morton, Edward T. Ferguson, Thomas J. McAllister, Alfred Horn and Thomas Hutchinson. The program included recitations, vocal and instrumental selections and brief addresses.

The supply committee was composed of Frank Martin, Fred L. Jahn, W. J. Brice, Charles Hopper, Harry Souder and Harry N. Winner, all of Philadelphia.

The ladies were taken on trips throughout the city and vicinity in automobiles, starting from the Y. M. C. A. building.

Friday morning the business session began at 9:30 o'clock. In the afternoon the delegates and the ladies were the guests of the West End Boat Club, at the organization's handsome headquarters at the foot of Central Ave.

Among the exhibitors were:

Cyrus Borgner Co.
United States Graphite Co.
William C. Robinson & Son
Greene, Tweed & Co.
Philadelphia Grease Mfg. Co.
Jenkins Bros.
John R. Livezey
Watson & McDaniel Co.
"Power"
Dearborn Chemical Co.
Lunkenheimer Co.
Ford & Kendig Co.
The Garlock Packing Co.
Harrison Safety Boiler Works
Keystone Lubricating Co.
Warren Webster & Co.
Westinghouse Electric & Manufacturing Co.
The Wickes Boiler Co.
Thomas C. Warley & Co.
Under Feed Stoker Co. of America
N. Y. & N. J. Lubricant Co.
Local Steam Packing Co.
Lagonda Manufacturing Co.
Anchor Packing Co.
H. B. Underwood & Co.
Dixon Crucible Co.
Peerless Rubber Co.
"National Engineer"
H. W. Johns-Manville Co.
Robert Wetherill & Co.
Berry Engineering Co.
Harper Packing Co.
Rooksby Engineering Co.
Economy Iron Works
Benjamin F. Shaw & Co.
Delaware Electric & Supply Co.
R. & J. Dick, Ltd.
Joseph F. Schiller.

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Ohio N. A. S. E. Convention

The Ohio State Association of the National Association of Stationary Engineers held its sixteenth annual convention in Toledo on June 11, 12 and 13. The exhibits and business sessions were held in Memorial Hall while the hotel headquarters were at the Boody House.

The first session was called to order on Wednesday morning by F. E. Smalley, chairman of the local committee. The Rev. E. B. Allen pronounced the invocation.

Charles H. Wirmel, chief examiner of stationary engineers for Ohio, and representing Governor Cox, spoke principally of the things accomplished last year in the stationary engineering field in Ohio. The boiler-inspection laws, already strong, were made even stronger by incorporating in them some important rules of the department. The history and condition of every one of the 20,000 registered boilers were carefully recorded so that complete data exist of a boiler's employment practically from the time it leaves the shop until it is scrapped. There are now 17,000 licensed engineers in the state and last year over 60 convictions for violation of the license laws were secured.

There was also established a department of engineering research at the state university which is available for the solution of steam-engineering problems as well as others.

Commissioner of Police Mooney represented Mayor Brand Whitlock, who was unavoidably absent. National President John F. McGrath gave a short outline of the history and work of the association, dwelling particularly upon the work of the past year.

Mr. Biggers, secretary of the Toledo Commercial Club, welcomed the delegates on behalf of the business men of the city. National Secretary Fred Raven, in the course of his remarks, told of the great need of adequate license laws in Illinois—laws similar to those of Ohio and Massachusetts. He also mentioned the need of advertising the N. A. S. E., its aims and its work, not only among the engineering but among all classes so that the good purposes for which it is working may be the more speedily accomplished.

At the formal opening of the mechanical exhibit, E. J. Jacques spoke briefly in place of President Osborne, of the Central States Exhibitors, who was detained elsewhere.

Among the numerous matters acted upon was the adoption of a resolution to fix the date of the first day of the annual state convention for the second Wednesday in June. Another resolution recommended that provision be made to examine the district examiners of stationary engineers by a board of practical and experienced engineers to determine their fitness and proficiency. This resolution and one recommending that the existing fee of $2 for renewing a license be abolished were referred to the legislative committee.

At the final business session the following officers were elected: President, J. E. Radigan; vice-president. W. D. Spangler; secretary, D. E. Kennedy; treasurer, John Wirmel. The new officers were installed by National Secretary Fred Raven assisted by E. J. Jacques. Akron was selected as the place for the next annual state convention.

This convention was unusual in that no educational features were provided. At most state conventions at least two or three papers or lectures are given. The explanation may lie in the fact that the Ohio state organization is a particularly large one and, consequently, the volume of association business, etc., to be accomplished is very great. The mechanical exhibit, which was especially large and interesting, was well attendad by delegates and visitors. Over 50 booths were occupied by the members of the Central States Exhibitors Association.

The entertainment features were well planned. On Wednesday afternoon the ladies enjoyed an auto ride about the city. On both Wednesday and Thursday evening an informal musical entertainment was given in the exhibit hall. On Thursday afternoon a trolley ride around the beautiful Maumee Valley belt was enjoyed by both delegates and guests; enroute, stops for inspection were made at the filtration plant and several industrial works. The big feature of the entertainment program, however, was an excursion on Lake Erie on Friday afternoon and evening. The large modern lake steamer "State of New York" left Toledo at 1:30 p.m., with nearly 1000 delegates and guests aboard and returned at 9:30.

The state organization of the Ladies Auxiliary held a business session on Thursday and consummated plans for organizing "Winship" Auxiliary No. 10 of Ohio. National President Olive Heckler telegraphed permission to perform the instituting ceremonies during the Friday excursion. State Deputy Josephine Lerch, to whose efforts the creation of the auxiliary is largely due, performed the instituting ritual, assisted by Past National President Florence Delaney and National Secretary Fred Raven.

The following officers were elected: Past president, Mrs. L. Long, president, Mrs. Thomas Winship, in honor of whose husband, "Uncle" Tom Winship, the organization was named; vice-president, Mrs. Mable Smalley; recording secretary, Mrs. F. M. Moran; financial secretary, Mrs. Clara Moore; treasurer, Mrs Mabel Chamberlin; conductor, Mrs. May Jacob; chaplain, Mrs. Doll; herald, Mrs. Betts; doorkeeper, Mrs. Brown.

This is the second auxiliary to be instituted by Sister Lerch. It is the largest in Ohio and said to be the second largest in the United States, 77 charter members being enrolled.

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Connecticut State N. A. S. E. Convention

The 18th annual convention of the Connecticut State Association of the National Association of Stationary Engineers was held in Meriden, Conn., June 26, 27 and 28, with headquarters at the Winthrop Hotel.

The auditorium of the city hall was tastefully decorated and arranged in booths by the local committee for the supplymen's exhibit of power-plant machinery and supplies, 50 booths being occupied for this purpose. The several sessions of the delegates were held on the upper flow of the auditorium. There were 90 delegates in attendance.

The convention was formally opened at 12 o'clock noon, on Thursday, with a short address by Frank Hastings, chairman of the local committee, who introduced Mayor Daniel J. Donovan. Mr. Donovan gave the delegates and visitors a hearty welcome to the city, and hoped their stay would prove a pleasure and a profit. National Vice-President James R. Coe

sponded for the engineers, and the ceremonies closed with short address by State President Thomas J. Phillips.

The principal feature of entertainment was the Dutch upper at Mefferts Terrace Garden. Music, speeches and ongs helped to make the occasion merry.

At the closing session of the engineers the following state ficers were elected: President, Bernard C. Reynolds, New aven; vice-president, Charles M. Dowd, Bridgeport; secre-ry-treasurer, John Galvin, Meriden; conductor, James J. cGee, Hartford, doorkeeper, James A. Austin, Norwich; ate deputy, Richard J. Greene. Thomas J. Phillips, Warren . Goodrich and Charles H. Ostrander were chosen as trustees.

The officers elected by the Connecticut State Supplymen's

ing & Ventilating Engineers, which is to be held in Buffalo on July 17, 18 and 19, promises to be most interesting and instructive. Several papers are now in hand and these, combined with the tests to be conducted during the session at the Bureau of Thermal Research, will place the members in possession of considerable valuable data. The committee on tests has arranged to conduct tests of piping systems and heating boilers, also a special test of fan blast heaters in connection with a paper discussing the relative efficiency of pipe coils and fan-blast heaters. In all probability there will be a paper explaining the use of charts for determining the sizes of pipes for gravity hot-water heating systems; one on the time element in heating apparatus; another com-

Delegates and Guests at Connecticut N. A. S. E. Convention

ssociation were: Fred Upson, president; Nelson D. Merwin, ce-president; Harry N. Glynne, secretary-treasurer.

The 1914 convention will be held in Bridgeport.

EXHIBITORS

agle Oil & Supply Co.
ratt & Cady Co.
eerless Rubber Mfg. Co.
he Garlock Packing Co.
. W. Harris Oil Co.
lbany Lubricating Co.
artford Mill Supply Co.
he Taylor-Flagg Co.
he Lunkenheimer Co.
ightingale & Childs Co.
hiladelphia Grease Co.
cClave-Brooks Co.
. S. Mersick & Co.
eystone Lubricating Co.
otfield Furnace Specialties Co.
. D. Anderson Co.
he Welding Co.
earborn Chemical Co.
enkins Bros.
cLeod & Henry Co.
shcroft Mfg. Co.
onsolidated Pop Safety Valve Co.
ancock Inspirator Co.
ayden & Derby Mfg. Co.
merican Metal Hose Co.
. W. Johns-Manville Co.
Evans Mill Supply Co.
Roto Co.
"Power"
Durabla Mfg. Co.
Ashton Valve Co.
Walter G. Buggles Co.
Greene, Tweed & Co.
Economy Lubricating Co.
Travelers Indemnity Co.
"National Engineer"
Mason Regulator Co.
Quaker City Rubber Co.
United States Graphite Co.
American Steam Gauge & Valve Mfg. Co.
New York Belting & Packing Co.
L. Sonneborn Sons, Inc.
"Southern Engineer"
Crane Valve Co.
Economy Fuse & Mfg. Co.
Engineering & Supply Co.
Durabla Mfg. Co.
Wm. M. Wheeler
Clement Restim Co.
Strong, Carlisle & Hammond Co.

SOCIETY NOTES

The 15th annual outing of the New York Association James ratt No. 7, N. A. S. E., will take place on Sunday, Aug. 3, at ouglaston, Long Island. The main feature will be a genuine ong Island clambake. Every member of No. 7 has appointed imself on the executive committee and a good time is, there-ore assured.

The Combined Engineers' Associations of Cleveland and orthern Ohio will hold their second annual picnic and out-ig on July 20, at Luna Park. There will be motor races, aseball and athletic sports, a prize drawing for engineers nd their wives, and "prizes for everybody and a good time or all." The members of the executive committee are: H. J. aier, W. Chas. Clarke, Thos. W. Roberts, Albert Ihlenfield, eo. P. Klasgye, Daniel Robinson, Edward Guentzler and hos. B. Eaton.

The summer meeting of the American Society of Heat-

prising a report of the work on ventilation conducted by Prof. Frederic Bass at the University of Minnesota, and another on some phase of the work of the ventilation department of the Bureau of Health, Chicago. There will also be a paper discussing the loss of pressure due to elbows in the transmission of air through pipes.

Hotel Statler has been selected as headquarters. The sessions, with one exception, will be held in the convention hall of the hotel. The first session will be convened at 10 o'clock, a.m., July 17. There will be an afternoon session on the same day, forenoon and afternoon sessions on July 18, and a forenoon session on July 19. The committee on entertainment promises that those attending may look for diversions of an unusually attractive nature.

New York engineers will hold outings on Sunday, July 20, No. 23, N. A. S. E. outing, at Eitners, Grant City, Staten Island. Sunday, Aug. 3, No. 7, N. A. S. E. outing at Bartletts Inn, Douglaston, L. I. Sunday, Aug. 10, No. 44, N. A. S. E., outing at Eitners' Grant City, Staten Island. Sunday, Aug. 17, Phœnix outing at Donnelly's, College Point, L. I. Sunday, Aug. 24, Blue Club, of Newark, N. J., outing at Olympic Park, Newark, N. J.

PERSONALS

George Westinghouse was awarded the Grashoff gold medal of the Society of German Engineers at the annual meeting of the society at Leipzig on June 23.

President Charles A. Coffin, after more than thirty years' service with the General Electric Co. and its predecessors, has retired, and has been succeeded by Edwin W. Rice, Jr., senior vice-president of the company. Mr. Coffin will remain chairman of the board of directors.

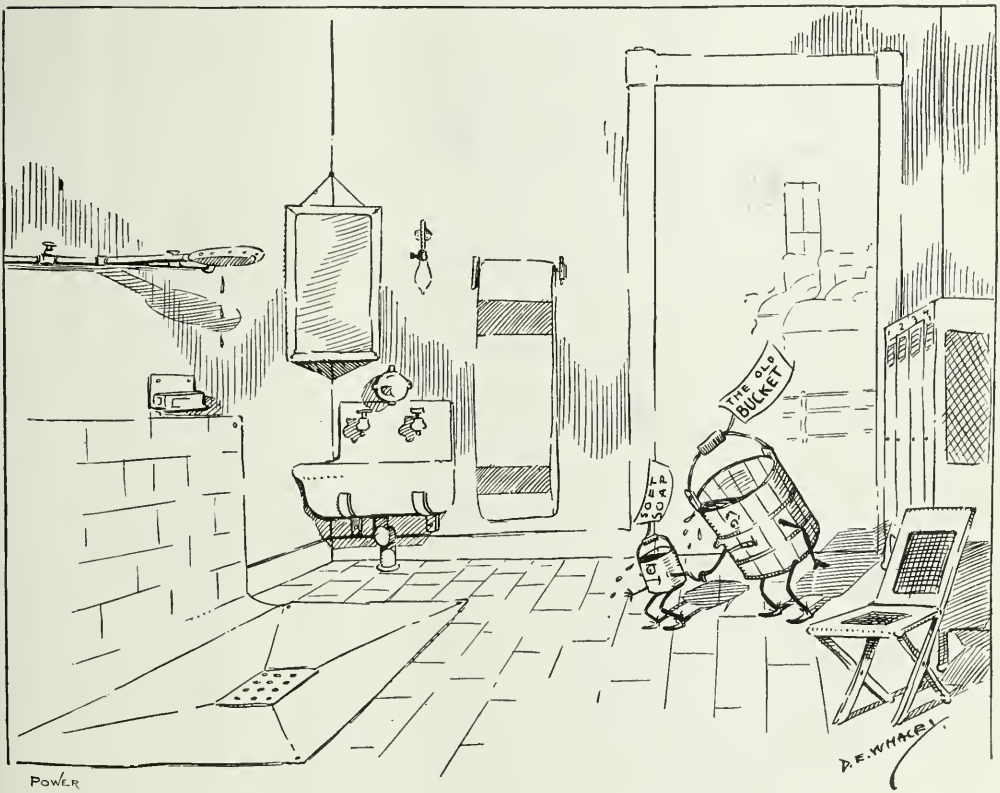
M. J. Kehoe has been appointed electrical engineer of the Ohio Electric Ry. in charge of power houses and substations, with offices at Springfield, Ohio. Mr. Kehoe was formerly connected with the Fort Wayne & Northern Indiana Traction Co. in a similar capacity for 13 years.

James H. Stretton, chief engineer of the W. H. Constable Cold Storage plant, El Paso, Tex., was married on June 18, to Miss Ruth E. McMullen, Los Angeles, Calif. Mr. Stretton was until recently engineer of the Baltimore Hotel, Los Angeles. He is a member of the National Association of Stationary Engineers.

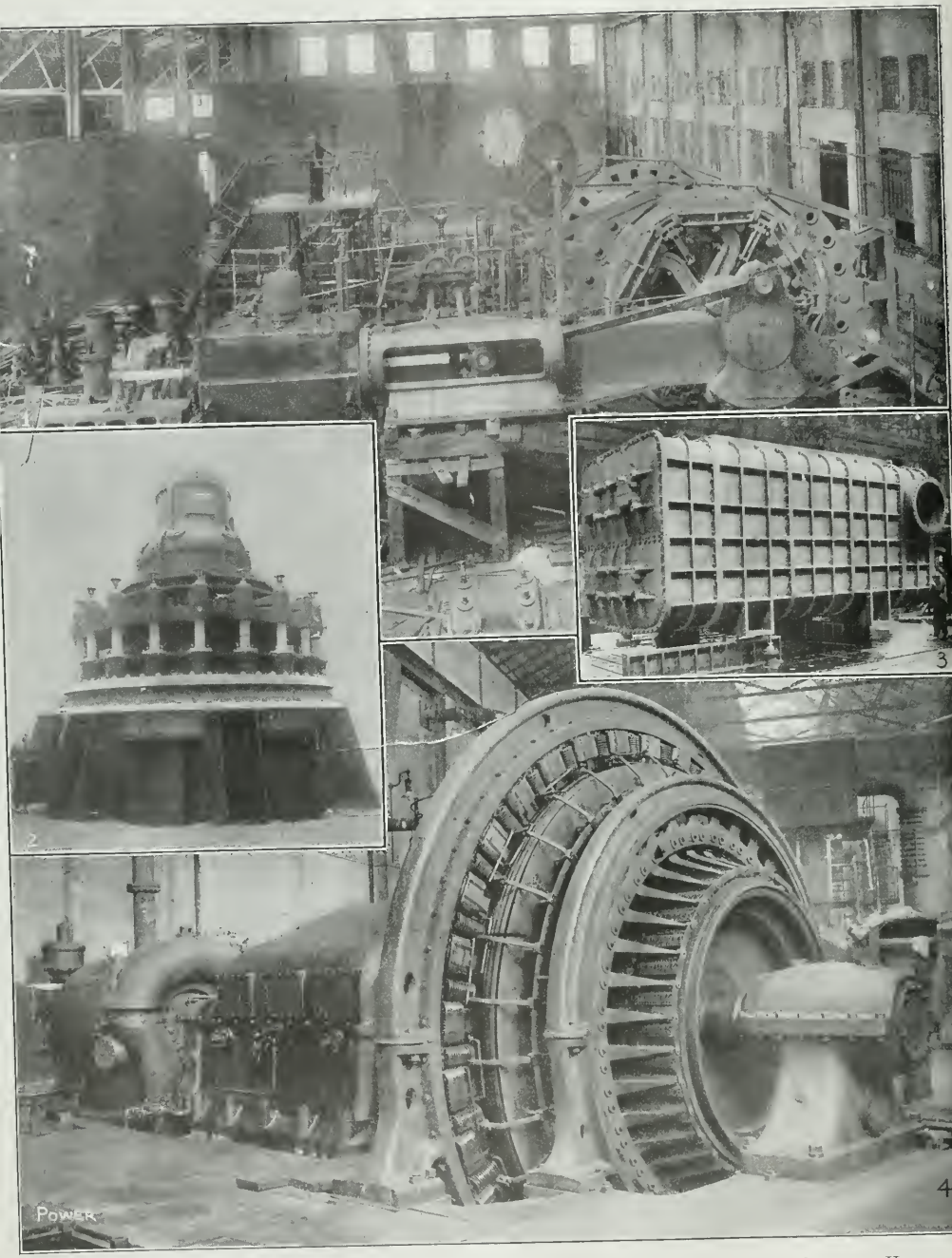
POWER

Vol. 38 NEW YORK, JULY 22, 1913 No. 4

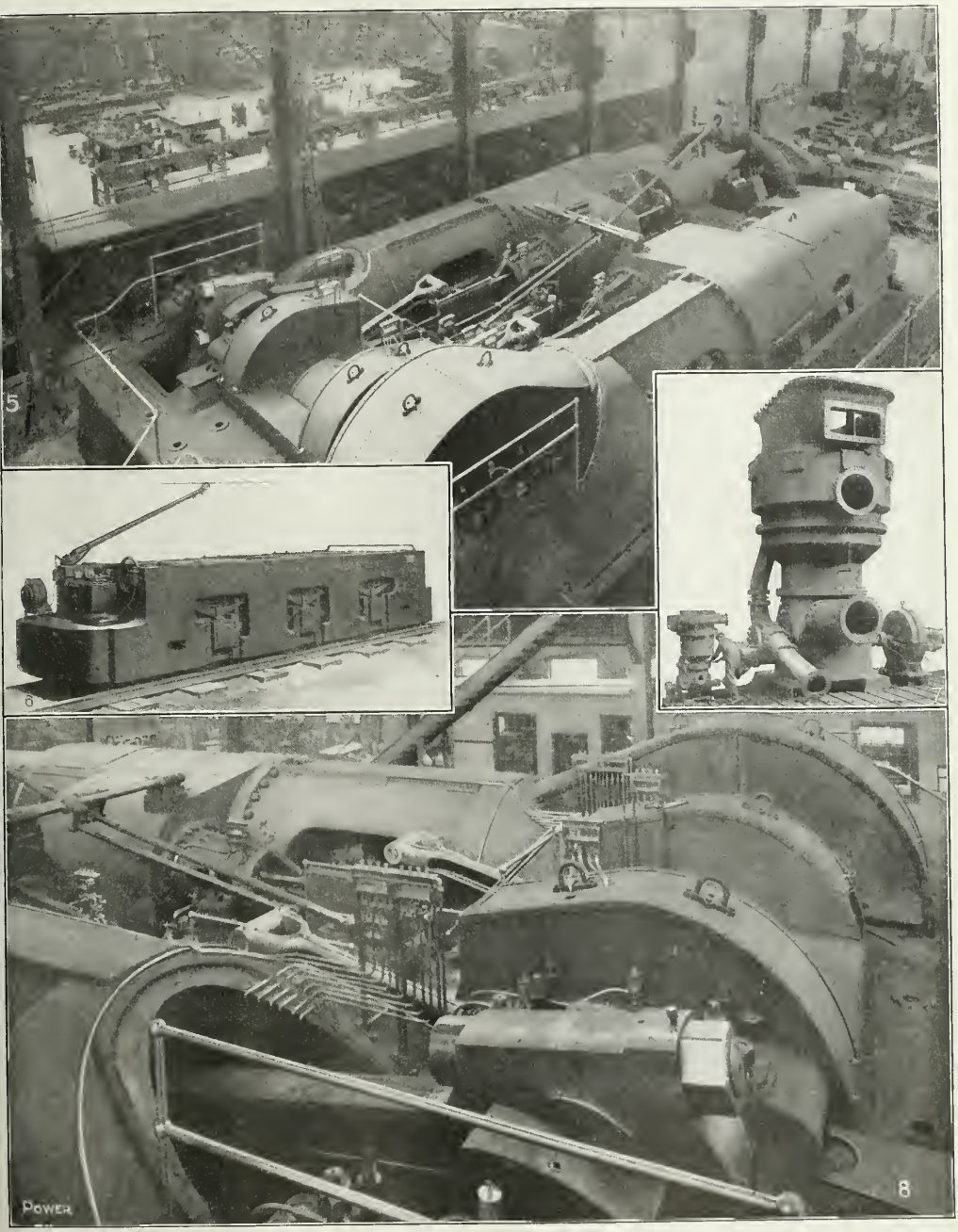
Not Wanted



THE BUCKET: "COME ON, OLD CHAP; THERE'S NO PLACE FOR US AROUND HERE."



Largest Known Units of Their Kind in the World. Fig. 1. Twin, 34 and 34x72-In. Nordberg Hoisting Engine. Fig. 2. A 10,000-Hp. Turbine at Keokuk, Weighing 1,000,000 Lb., Cast in One Piece by the Wellman-Seaver-Morgan Co. Fig. 3. Westinghouse Surface Condenser to Serve a 20,000-Kw. Turbine, Condensing 300,000 Lb. of Steam per Hour. Fig. 4. Geared 3750-Kw. Shunt-Wound D. C. Westinghouse Generator



FIGS. 5 AND 8. MESTA TWIN TANDEM-COMPOUND ROLLING-MILL ENGINE. HIGH-PRESSURE CYLINDER, 46-IN. LOW-PRESSURE CYLINDER 76 IN., STROKE 60 IN. FIG. 6. THREE-MOTOR, 25-TON JEFFREY ELECTRIC MINE LOCOMOTIVE. FIG. 7. WESTINGHOUSE-LE BLANC JET CONDENSER TO SERVE A 12,500-KW. TURBINE, CONDENSING 150,000 LB. OF STEAM PER HOUR

Duchesne's Experiments on Superheat

By Prof. R. C. H. Heck

SYNOPSIS—Duchesne determined the specific volume of steam by using the steam-engine cylinder, during the operation of compression, as the containing and measuring vessel. He got the quantity of steam present by an assumption of homogeneity of steam condition throughout the compression space. It is shown that his method has led to values as much as 40 per cent. greater than what is physically possible.

The determinations of total heat were made by the method of water calorimetry. While this method was used by Regnault, it is not of the highest accuracy, and has been abandoned by the more skillful of the later experimenters. The results of Duchesne show good instrumental work, in that they are consistent among themselves. But an error is made in assuming that they are in accord and can be combined with Regnault's values at saturation. And in the variation of total heat with pressure for a given temperature they show rates of change far greater than can be accepted as possible.

The writer has recently had occasion and opportunity to make a critical examination of the full report of the Duchesne experiments on certain properties of superheated steam, an abstract of which was published in POWER for July 23, 1912. The results deduced from those experiments disagree radically with the great body of data which has gradually been formulated into our modern steam tables. If they are valid, the steam tables are ready for the scrap heap; but it is not difficult to find errors or inaccuracies in the work of Duchesne quite sufficient to account for the discrepancies which appear. This work divides itself into two distinct sections, concerned with specific volume and with total heat, respectively. The scheme followed in determination of volume is outlined in Fig. 1. The cylinder of a steam engine served as containing vessel, volume and pressure were measured from the compression curve of the indicator diagram, variant steam temperature was given by the "hyperthermometer," and weight of steam present was inferred through an assumption of homogeneity which works out badly.

The engine is approximately of 12 in. diameter and 12-in. stroke. The head end, which alone was used in these experiments, has a piston displacement of just 1.52 cu.ft., and the clearance volume (increased in order to accommodate very long compressions) was 8.6 per cent. of the displacement. The clearance distance shown in Fig. 1 bears, of course, a smaller ratio to the stroke MN. As nearly as can be inferred from vague information, the wires of the hyperthermometer or multiple-junction thermocouple lie in a plane about 1 in. from the cylinder head, as indicated by line TT. The engine was operated at a speed of either 15 or 30 r.p.m.

Duchesne's Scheme for Measuring Specific Volume

The curves plotted in Fig. 1 show steam temperature on a base of piston position, two typical experiments being represented. In No. 11 the engine was run condensing, in No. 20 noncondensing. Curve a in either case gives observed steam temperature, while curve b is laid out by taking the saturation temperature corresponding to indicated pressure; then any vertical distance between the curves shows superheat existing. The distinctive feature of No. 20 is found in the fact that the two curves coincide at first, then separate at a point K where superheating begins. Duchesne assumes that at this point the whole body of steam has arrived at a uniform state of dry saturation, throughout the contained space, so that with density read from the steam table its exact weight becomes known. And when there was superheating even at the beginning of compression, as in experiment 11, it was still assumed that the steam was uniform in condition and due allowance (or, as will appear later, undue and excessive allowance) was made for this initial superheat.

Volumetric Experiments of Knoblauch, Linde and Klebe

Contrast with this the Munich experiments, which were published in 1905. Into the glass bulb B, Fig. 2, was introduced, over mercury, a small and very accurately weighed quantity of pure water. In any experiment, saturated steam from a boiler filled the cast-iron cylinder A; and with the water in B all evaporated, the mercury level was kept at a height LL in tube P, which tube led to the manometer. Both pressure and temperature of the steam in A were read; and since steady conditions could easily be maintained for any needed length of time, existence of the same temperature in B was assured. Even the stem P was surrounded by the steam bath to a point below the mercury level, the latter being observed through glass windows WW. For superheat in B there had to be higher pressure in A, which the glass vessel was strong enough to sustain. Several of these bulbs were used, of capacity ranging from 104 to 183 cu.in.

Comparison of Volume Results

A comparison of results is made in Fig. 3. Consider first the full lines, which represent a formulation based on the Munich experiments and checked by other reliable data. In general, if superheated steam or gaseous H_2O were a perfect gas, it would exactly follow the law

$$pv = BT \qquad (1)$$

Here p is absolute unit pressure, v is the volume of a unit weight of the gas, T is absolute temperature, and B is the gas constant, fixed by the molecular weight of the substance. With our ordinary practical units, or with p in pounds per square inch above perfect vacuum, v in cubic feet to the pound of steam, and T in Fahrenheit degrees (so that it equals thermometer reading t plus 460), the value of B is 0.596, as against 0.370 for air. This 0.596 corresponds with 47.1 for kilograms per square meter, cubic meters to the kilogram, and centigrade degrees. The gas constant is a quantity of the first importance in any attempt to relate volume to pressure and temperature.

Far from saturation or liquefaction, actual gases conform closely to the law $pv = BT$. But as they approach saturation there is a gradual shrinkage of the pressure-volume product pv from the ideal value BT. The formula

connecting pressure, volume and temperature, or the characteristic equation of steam, may then be most simply written as

$$pv = BT - X \qquad (2)$$

where X stands for a complex corrective or modifying term. This X depends upon both pressure and temperature; it increases with higher pressure, but for any pressure it has a maximum value at saturation and decreases as temperature rises.

In Fig. 3, the base is temperature, the ordinate is product pv for 1 lb. of steam, and the operation represented is heating (or cooling) under constant pressure. In the full-line diagram, straight line AA represents equation (1), since it shows pv varying with t or T in constant ratio. Produced toward the left, AA would cut the line of zero pv at absolute zero of temperature. Curves BC, DE and FG are actual lines of constant-pressure expansion, having their lowest points on the saturation curve BFH and continually approaching AA as temperature rises.

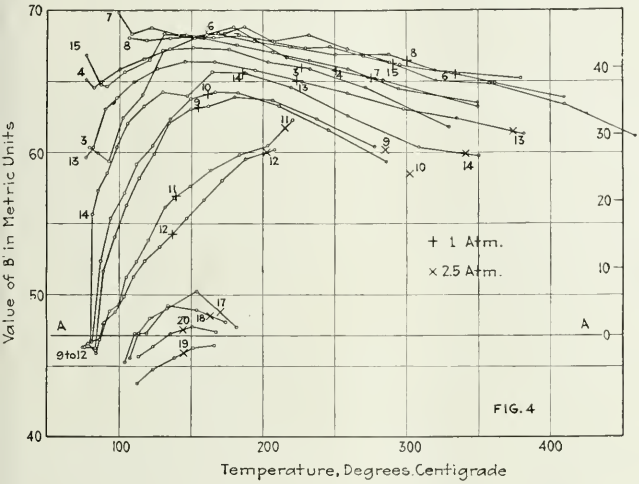
Lines BC and DE are for 1.0 and 2.5 atmospheres absolute pressure, the same as the dotted Duchesne curves 1 and 2.5 above. Within the low-pressure range of the experiments, the shrinkage term X is small. To show larger values, curve FG is laid out for 250 lb. absolute. Of course, any vertical intercept such as KL represents a particular value of X. The vertical FN, dropping from the saturation line, shows how the line of constant-pressure change runs into the region of steam-and-water mixture.

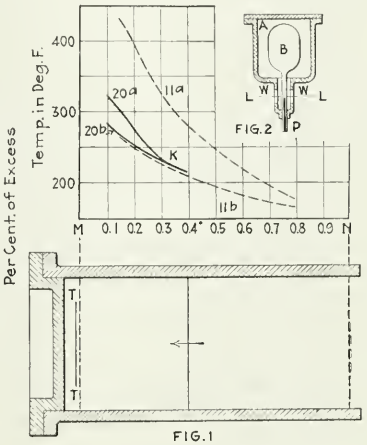
The points which determine dotted curves 1 and 2.5 in Fig. 3 represent the writer's interpolations in Duchesne's tables of readings, each point bearing the number of the experiment from which it comes. The curves here drawn agree in form with those of the original report, which have been reproduced in Fig. 2 on page 111 of POWER for July 23 last. The striking features of these curves are, a start in the region of line AA, a steep climb to excessive values of pv, then quite good conformity to the law $pv = BT$, except that B is much too big and is not the same for the two pressures. Straight lines $A'A'$ and $A''A''$ pass through the absolute zero of temperature like AA, therefore, each represents an equation of the form $pv = BT$.

Now there is absolutely no reason in physical science for believing that the pressure-volume measure pv for 1 lb. of steam can possibly extend above the ideal gas line AA in Fig. 3. The unavoidable alternative is the belief that the Duchesne values of pv are too big, or that they really belong to more than the unit weight of steam.

Duchesne's Values of Product pv

The method of getting numerical values of pv from the experimental data is to take the product of measured pressure and volume and divide it by assumed steam weight M. If M is less than the true weight present, pv will be too large; conversely, if pv is greater than BT, it must correspond with more than the unit weight. An analysis along the line of these ideas is given graphical form in Fig. 4. Without going into the detail of the psychological processes by which Duchesne gets at his values of steam weight M, the purpose is to try out his results against the criterion of underlying physical principle.





The scheme here employed is then, to take pv as given for the kilogram of steam, divide it by the corresponding T, and plot in Fig. 4 the quotient

$$B' = \frac{pv}{T} \qquad (3)$$

This B' is not a constant; but if the derived values of pv were really correct and consistent, it would come out just a little smaller than the true constant B, the difference varying with pressure and temperature after a manner suggested by the relation of curves BC and DE to line AA in Fig. 3. The quantities being left in the original units, horizontal line AA, at the height 47.1, here represents the true value of B, which B' ought not to exceed. A scale at the right shows percentage of excess of B' over B.

In Fig. 4, the points belonging to each experiment are strung together by short tie lines to form a rough curve.

Sixteen experiments were worked up. In amount of compression, expressed as a fraction of the stroke, and in speed of engine, they classify as follows:

RUNNING CONDENSING

Compression 0.9	No. 15
Compression 0.8	Nos. 9, 10, 11, 12
Compression 0.75	Nos. 13, 14
Compression 0.65	Nos. 3, 4
Compression 0.6	Nos. 6, 7, 8

NONCONDENSING

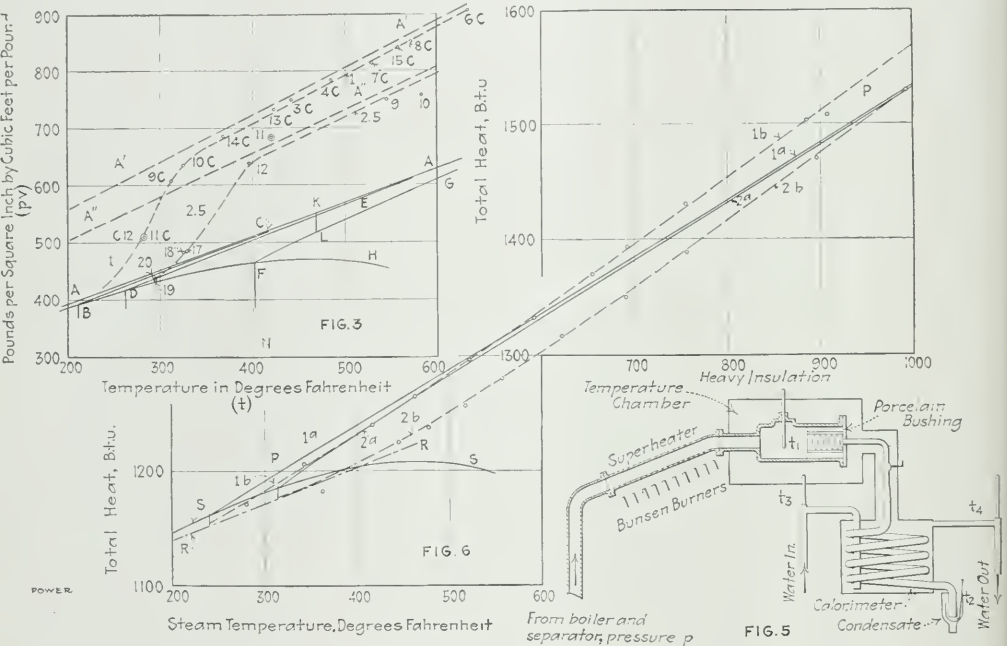
Compression 0.4	Nos. 17, 18, 19, 20
Speed about 15 r.p.m.	Nos. 6, 9, 10, 15, 17, 18
Speed about 30 r.p.m.	Nos. 3, 4, 7, 8, 11, 12, 13, 14, 19, 20

A marked and rapid rise of B', most strikingly shown in the Nos. 9 to 14 group of curves, surely indicates reevaporation continuing past the point where Duchesne

The Assumption of Homogeneity

Is there any reason to assume uniformity of steam condition throughout the compression space of an engine cylinder at any instant? Powerful influences exist which tend to produce variation, and there is strong evidence that variation once established will disappear slowly.

During the last part of compression and during admission, a portion of the steam within or entering the cylinder is condensed by cooler metal walls. On some surfaces the water of condensation probably lies more or less quietly, in a film, until pressure falls. But where steam rushes over a surface, the moisture will be swept off as rapidly as formed, and mixed with the body of steam.



assumed uniformity of condition and absence of moisture; in other words, there are increases in the amount of water substance present in gaseous form. The curves in another group, made up of Nos. 4, 6, 7, 8 and 15, show practically none of this initial rise, but they begin and have their whole course in a region about 40 per cent. above any possible true value for the kilogram of steam. Evidently, there was something radically wrong with the method of allowing for initial superheat when estimating steam density.

Large cross-marks on the curves in Fig. 4 locate the points interpolated for plotting in Fig. 3, and thus give some idea of the relation of pressure to the quantities here diagrammed. The evolution of Duchesne's curves of constant-pressure expansion can be traced out in this diagram, but a detailed discussion is hardly worth while. One matter of interest is the drop of nearly all the B' curves, with rise of temperature, after passing a maximum. This is what makes the upper part of curve 2.5 in Fig. 3 lie so much below curve 1.

When pressure falls in expansion and at release, a wall that is wet will dry itself, partly by straight reëvaporation, partly by mechanical action; that is, a layer of steam formed between metal and water will throw the latter off into space. A wall already swept dry will at once begin to dry and superheat the steam in contact with it. The larger body of steam, away from the walls, contains moisture thus swept or thrown from the walls and also moisture due to loss of heat in work performed.

It is futile to claim that even a multijunction thermocouple, located in a plane parallel to the cylinder head as indicated by line TT in Fig. 1, is in position to measure the average temperature of the whole mass of steam in the cylinder, especially during the early part of compression, although its position becomes relatively better as the piston gets closer to the head. Of all the surfaces of the cylinder proper (in distinction from the steam passages), the face of the head is most definitely swept by the current of entering steam. This surface is, therefore, ready to begin superheating promptly. A layer of

steam initially dry or slightly superheated will have its temperature rapidly elevated by the work of compression, while an adjacent body of initially wet steam must be dried by the same source of heat before its temperature can rise above that of saturation. In the experiments, the thermocouple is located just where the rapid superheating which it shows is most strongly favored.

Determination of Total Heat

Total heat was measured by the method of the continuous water calorimeter, with the apparatus arranged as sketched in Fig. 5, where all nonessential detail has been omitted. Temperature t_3 of the superheated steam was got by a bare mercury thermometer entering through a stuffing box and by the thermocouple. The other temperatures, all of low range, were taken with fine mercury thermometers. Numerical values from one of the three experiments which are reported in full will give an idea of the size of the quantities involved.

1	Number of experiment	40
2	Absolute steam pressure, lb.	69 7
3	Saturation temperature, deg. F.	302.7
4	Temperature of superheated steam, t_3, deg. F.	436 4
5	Rate of condensation per hour, lb.	5.48
6	Temperature of condensate, t_2, deg. F.	58.43
7	Initial temperature of cooling water, t_0, deg. F.	55.59
8	Final temperature of cooling water, t_1, deg. F.	59.35
9	Rate of flow of cooling water per hour, lb.	1704
10	Apparent total heat by calorimeter, B.t.u	1190 5
11	Correction for radiation beyond temperature chamber, B.t.u.	+53 9
12	Expermental total heat, B.t.u.	1244.4

The first thing to be noted is the small amount of steam put through the apparatus. With 70 lb. pressure, the rate of flow is 5.5 lb. per hr. The other two fully recorded experiments have the rates, 9.4 lb. at 84 lb. pressure, and 5.9 lb. at 28 lb. pressure. In the Knoblauch experiments on heat required for superheating the steam rate was from 60 to 110 lb. per hr.

The rise of temperature of the cooling water is between 3 and 4 deg., so that even with thermometers graduated to 0.01 deg., it is limited to the accuracy expressed by a three-figure number. And the other factor in calorimetry, the quantity of cooling water, is of no greater precision, because it was found by a float reading of the head over an orifice in a thin plate. With such data, it really seems foolish to carry the calculated heat values to three decimal places, or to six-figure accuracy (in calories). However, the results show excellent consistency in one direction, for the points agree very well with smooth curves traced through the several series belonging to the particular pressures.

A permissible question arises as to the validity of disregarding radiation from the temperature chamber, or of assuming that the temperature given by the hyperthermometer is truly representative. This chamber was about 2 in. in full diameter, but was contracted to something like half that size by a porcelain bushing, around the location of the thermometer wires. There certainly must have been some loss of heat through the lagging, which would cool the steam near the walls. The junctions of the thermocouple all lay right in the axis of the chamber and of the steam current, and the flow of steam was so gentle that some degree of annular stratification was likely to persist clear over to the orifice. The thermocouples used in the Knoblauch-Mollier experiments—which Duchesne, in a discussion in *Révue de Mécanique*, has erroneously taken for thermometer cups—being placed in the vertical ends of the serpentine coil itself, are a good deal more likely to have been subjected to the real, average temperature of the current of rapidly flowing steam.

The character of Duchesne's results is shown in Fig. 6, where points are plotted and curves drawn for two of the seven pressures at which series of experiments were made. No. 1 is for 26.9 lb. absolute, No. 2 for 84.2 lb., while the highest and lowest pressures were about 16 and 100 lb. Dotted curves $1b$ and $2b$ are from the tabulations in the report, but full-line curves $1a$ and $2a$ represent a formula for total heat recently established by the writer. These last run a few heat units higher than would similar curves from the Marks and Davis tables, but in the important matter of relative form and spacing there would be no distinguishable difference.

It need hardly be stated that the curves of class *PP* in Fig. 6 are lines of constant-pressure expansion. Curve *SS* is the writer's saturation line, straight line *RR* represents Regnault's formula for total heat of saturated steam. As has been remarked, the experimental points in Fig. 6 agree very well with their curves, except where the lower end of No. $2b$ is bent up to meet the Regnault value at saturation. The assumption that Regnault's total heats may thus be brought into combination with the present results is decidedly unwarranted, and is one of the chief reasons for the peculiar form of the curves of specific heat c_p which have been derived by Duchesne in the course of his work.

The experiments plotted in Fig. 6 have two outstanding features. First, the general slope of the b curves is somewhat steeper than that of the writer's curves, which latter are based upon the Knoblauch-Mollier experiments. This accounts for the high prevailing value of c_p in Fig. 4 of the article in POWER of July 23, where the curve into which those for various pressures finally run ranges from 0.55 to 0.60 in. in height. But there is nothing in these experiments to inspire the confidence that would lead one to substitute them for the others as a basis of knowledge.

The second special feature is the great vertical distance between curves $1b$ and $2b$. In the throttling experiments which have been made on steam and other gases we have definite (although not exceedingly precise) data as to the rate of change of total heat with pressure along lines of uniform temperature. The comparatively narrow distance between curves $1a$ and $2a$ in Fig. 6, and the gradual convergence of these curves as temperature rises, are not at all a matter of guesswork, but are wholly rational and in accord with the reliable data. Such a difference between the total heat at 27 lb. and 84 lb. pressure as the 35 B.t.u. between curves $1b$ and $2b$ is beyond the bounds of possibility.

Specific Heat of Superheated Steam

Duchesne applies the thermodynamic relations between rate of expansion and specific heat as a partial determinant for c_p; but since his results for volume have errors running up to 40 per cent., they hardly furnish a foundation for mathematically derived quantities. His direct measurements of total heat are by a method insufficiently accurate for the detection of small variations, their combination with the Regnault values at saturation leads to misinterpretation, and the excessive variation with pressure casts doubt on their correctness, even though no obvious sources of large error are apparent in his work and the subsequent presentation.

Welding Steam Boilers

NOPSIS—The safety of water-tube boilers employ- headers and the strength of welded seams.

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he June number of the *Journal* of the American So- y of Mechanical Engineers reviewed at some length rticle on the above subject, which was written by H. ger for *Zeitchrift für Dampfkessel und Maschinen- ieb.* It appears that three serious explosions of water- boilers with headers occurred in Prussia during the 1912. These explosions have attracted wide atten- to the question of safety of this type of boiler and of ded seams in boilers in particular.

he first explosion was in the central station of the enix Co., in Liereufeld. The boiler was built in 1910 he Borsic Co. It had 4108 sq.ft. of heating surface worked under a pressure of 205 lb. gage. The im- diate cause of the accident was the rupture of the ge plate in the lower part of the header which was ft. wide and 10 in. deep. The second explosion oc- red in the rolling mill of the Menden and Schwerte el Works, with a new Piedboeuf boiler built in 1911. ing a header 11.7 ft. wide by 11.8 in. deep. The im- diate cause of the explosion was the loosening of the ded seam of the header plate which sprung open up he corners. In the third explosion at the rolling mill tscher Kaiser in Dinslaken, a wall of the rear header me loose at the welded seam and rolled up to the nd row of stay-bolts. The boiler was built in 1897 a working pressure of approximately 160 lb. and, as , used furnace gases from the mill. In all three s, the explosions were violent, the boilers being thrown . 190 and 20 ft., respectively.

nvestigation showed that there were other causes be- s possible weakness of the welded seams, which in nselves might have been sufficient to account for the losions. In the Borsic boiler it was found that the er welded seam of the header was exposed to the di- action of the gases, owing to insufficient protection the boiler setting which had been defective for some e. Similar conditions were found in the Menden- werte explosion, while in the Dinslaken accident, it found that the lower row of stay-bolts was unusually from the welded seam, 8.9 in., and in that row six -bolts were broken and several more cracked.

Both the Prussian Government and the manufacturers e organized a series of tests to determine the strength velded seams generally. The Piedboeuf Co. has made eries of tests with butt-welded seams and found that ture occurred only at stresses many times exceeding se to which the seam would be subjected in boiler op- ion. The fracture showed a brilliant surface colored e and there by oxidized iron slag, the same as the sur- e of fracture of the exploded boilers. Since all pos- e care was exercised in the preparation of the test ns, and the welded pieces were sufficiently warm, it ears that, with the present methods of work, inclosure xidized slag cannot be prevented. With thick sheets, n as are used in water-tube boilers, the specific pres- e of the two welded surfaces against each other cannot made great enough by hammering to force out from joints the slag formed by the oxidizing-welding flame. following subjects were also investigated:

1. The advisability of limiting the width and depth of the header, the former when there are two upper drums. The use of two headers side by side would be as economical in operation as the two upper drums, while the handling of excessively large headers would be avoided. On the other hand, with the present hoisting apparatus, the single header does not present any serious difficulty, while two units would be more expensive than one and the total length of welded joint would be longer with the two units. It was decided that there was no reason for recommending a limitation of the width of the headers.

2. The advisability of adopting a header design, avoiding the use of butt welding entirely, or at least eliminating the lower welded seams of the headers lying toward the fire side, was investigated. The following types were considered: (a) Return to the riveting of the headers, either by connecting the side plate with the straight walls by means of angle irons, as in sketch *A*, or as in the Willman boiler, sketch *B*, by riveting together the front and rear walls, provided for this purpose with broad flanges so that the rivet joint lies in the middle of the flanges serving as side plate. (b) By flanging both walls and making an external riveted seam, as in sketch *C*. (c) By flanging the fire wall and butt welding

Types of Joint

to it the outer wall, sketch *D*. (d) By flanging both walls and autogenously welding them in the middle, as shown in sketch *E*.

The design shown in sketch *A* is not advisable because it does not insure complete safety of operation and the row of rivets on the far side forms a weak place in the boiler. This also applies to the design shown in sketch *B*. A seam, such as is shown in sketch *C*, would be expensive to make on account of the tall flanges of the inner walls and, in addition, is not absolutely safe as to tightness on account of there being only a single calking edge. Some factories now contemplate the adoption of the design shown in sketch *D*, which has the advantage of not having the dangerous inner welding seam.

3. All experts agreed that the stay-bolts should be placed as near as possible to the welded joints and not farther than 3 in. from the wall. As to the advisability of reinforcing the stay-bolts and drilling their ends, opinions differ; but it appears advisable to do so, since, in the Dinslaken boiler explosion it was found that six stay-bolts of the lower row had broken before the explosion, while several more had started to crack.

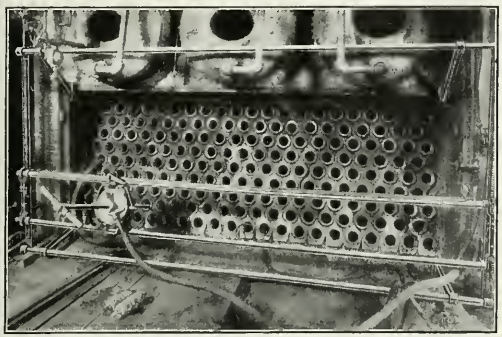
4. The proposal to test the headers at a pressure double that of the operating did not meet with favor. Considerably higher stresses are required to rupture the welded seam so that such a test would not really show much, and it is difficult to make the header water-tight. The high pressure may also start cracks in the header. The advisability of hammering up the seam with heavy hammers during the pressure test was universally recog-

nized as well as the possibility of injuring the seam by too heavy sledges. Tests are to be made to determine this point.

5. The question of annealing the headers after the execution of the welding work was considered; even though the boring of holes and opening in the header relieves the metal to a certain extent from the stresses created by the welding process, this is not complete, and a certain amount of stress remains. When annealed some of the weaker places open up, while other openings can be recognized by the coloration of the metal sheet when cooled.

A Novel Boiler-Cleaning Arrangement

In the power plant of the Colorado Springs & Interurban Ry. Co., Colorado Springs, Colo., the feed water is exceptionally bad and a very hard scale rapidly accumulates in the boiler tubes. It was impossible to remove this scale economically with any ordinary turbine or self-contained air-driven cleaner. Therefore, in order to expedite boiler-cleaning operations and to greatly decrease the time that a given boiler is kept out of commission for cleaning purposes, this company found it advisable to provide a special boiler-cleaning attachment.



Application of Steam-Motor-Driven Boiler-Tube Cleaner

A Weinland mechanical cutter head is used for removing the scale; it is driven by a Lagonda external steam motor, so designed that the square shaft carrying the cutter head can pass directly through the motor, and while revolving at high speed, can be worked back and forth in the boiler tubes, the motor remaining stationary upon the supporting frame. The motor is supported between rollers at the top and bottom and is given a horizontal motion on the two supporting bars by a small handle at the top of the motor, which turns a pinion operating on a rack on the top supporting bar.

To shift the motor vertically, the two horizontal bars supporting the motor are elevated by pinions operating on vertical racks, these pinions being operated by a crank handle. Both the horizontal and vertical pinions are held in place by pawls, so that after the motor has been adjusted in front of a tube, it remains stationary until the scale has been removed from that tube.

The motor can be driven by either air, steam or water pressure, and with steam at 100-lb. pressure, will develop 7 hp. The shaft supporting the cutter head is sectional and additional lengths are added as the cleaner is worked into the tubes, the handle being attached to the shaft by a swivel joint.

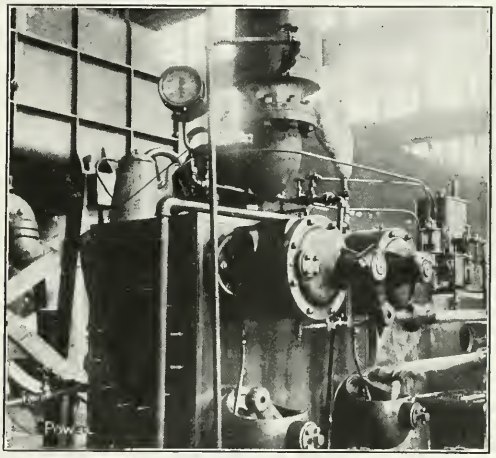
While an equipment such as this would not be recommended under all circumstances, it has, in this case, paid for itself many times over. For instance, C. E. Bibb, chief engineer of the power plant, states that this equipment quickly does the work on scale that was so thick and hard he formerly had to use a small block and tackle to force the cutter head against the scale.

This equipment was designed and installed by one of the engineers of the Lagonda Manufacturing Co., Springfield, Ohio, and has proved so satisfactory where the scale conditions are exceptional that several other similar equipments are being installed.

Test of Valve and Piston Tightness

A somewhat remarkable photograph is reproduced herewith of an engine running with the cylinder head removed and the head-end valves closed and disconnected from the valve-gear. This photograph has not been retouched and proves that the engine is in operation by the blur of the moving valve-gear parts.

The picture is from the Ball Engine Co., Erie, Penn., and shows one of its Corliss engines undergoing a test for the tightness of its valves and piston. The engine is operating as a single-acting engine, all of the head end being out of commission, and it is plain that no steam is escaping, although it is reported that a few drops of water were discharged intermittently.



Engine Running with Cylinder Head Removed and Head-End Valves Disconnected

It is especially creditable that this is a new engine and not one that has been operated for some time. The manufacturers admit that it is only recently that they have become able to make the valves of new engines so tight. Formerly it was more common to find an engine running better, so far as tightness of valves is concerned, after it had been in service two or three years.

At the time the picture was taken the engine was run-

ng at 220 r.p.m. under a steam pressure of 140 lb. The gine has a 12-in. cylinder and an 18-in. stroke and ves a duty of 20½ lb. per i.hp. per hour at three-uarters load with 140 lb. steam.

Worthington Rotary Air Pump

By W. Vincent Treeby

The following description is of an interesting con-enser auxiliary, a Worthington rotary air pump. Strict-speaking, this name is a misnomer, a more applicable tle being hydraulic vacuum pump.

The original Worthington rotary air pump was made

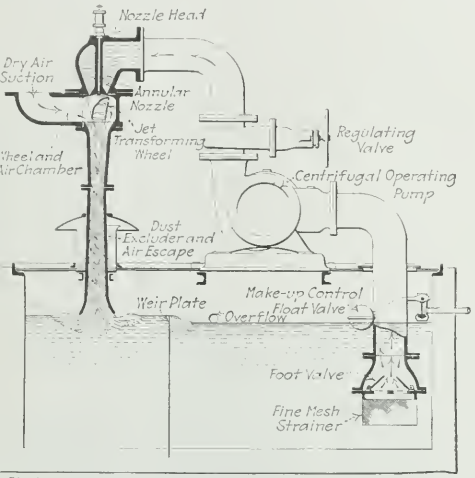


Fig. 1. Illustrating the Operation of the Rotary Air Pump

out two and a half years ago, and has since been in ntinuous service in connection with a manufacturing ower plant, maintaining a mean vacuum of 28 in. on a -in. barometer.

The design and construction of this apparatus is ex-edingly simple, so much so that its very simplicity has a way tended to oppose its use. This pump is, in fact, specially constructed ejector and consists essentially. four parts: The nozzle head, jet-transforming wheel, heel and air chamber and tail pipe containing the ector cone and diffuser.

The nozzle head contains an annular nozzle, which is tuated in the bottom of the nozzle head. Immediately nder the nozzle head is the jet-transforming wheel and r chamber. This transforming wheel transforms the nnular jet issuing from the annular nozzle into a num-r of jets of approximately rectangular cross-section. fficient space is left between these jets for the entry air and vapors from the condenser, vacuum pan or her apparatus being exhausted, which is connected up the side of the wheel chamber. The rotation of the heel imparts to the jets a rapidly revolving motion and, a result, the water jets rush through the ejector cone d diffuser in the form of a helix with pitch and veloc-y diminishing as the compression of the air and vapors goes on. The air and vapors entering around the rotating transforming wheel are promptly caught and inclosed by the issuing water jets, then are gradually compressed on the way down to the tail-pipe discharge. The transforming wheel is carefully balanced and finished with a highly polished inside surface. It is carried on a spindle rotating in ball bearings, which are easily lubricated.

The operating water is delivered to the nozzle head of the air pump by an ordinary centrifugal pump through a regulating valve. After entering the nozzle head, the water flows through the nozzle, wheel and tail pipe, and returns to the operating-pump tank, wherein the contained air is liberated before the operating water is

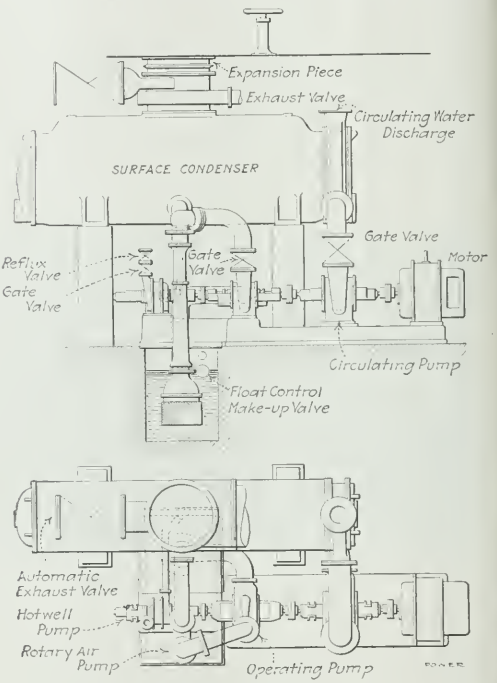


Fig. 2. Application of Air Pump to a Surface Condenser

again picked up by the operating pump and recirculated. After the water leaves the tail pipe it passes over a weir on its return to the operating pump. This weir is provided so as to assist the liberation of entrained air, and it also serves as a ready means of measuring the quantity of water in circulation. Fig. 1 illustrates the operation of this apparatus, and Figs. 2 and 3 show the application of the air pump to a surface condenser and to a low-level jet condenser, respectively.

A study of these diagrams will indicate the relatively small amount of space required for this type of air pump. The operating-pump tank shown arranged under the operating pump may be placed alongside or even above the pump, if the available space is extremely limited, as it will be apparent that the air pump itself may be placed in any convenient position, the connecting pipes being made to suit.

The operating tank is of quite small dimensions, as elatively little operating water is required, the tempera- ire of the latter being more or less independent of the icuum requirements, owing to what may be called the luctive action of the water jets from the transforming heel. In order to prevent the temperature of the op- ating water becoming excessive a small portion is by- assed into the injection supply to the condenser, when onvenient, or to waste, a makeup connection, auto- natically controlled, being arranged on the operating ank. This pump is particularly suitable for a variable oad and requires no attention. If the load increases

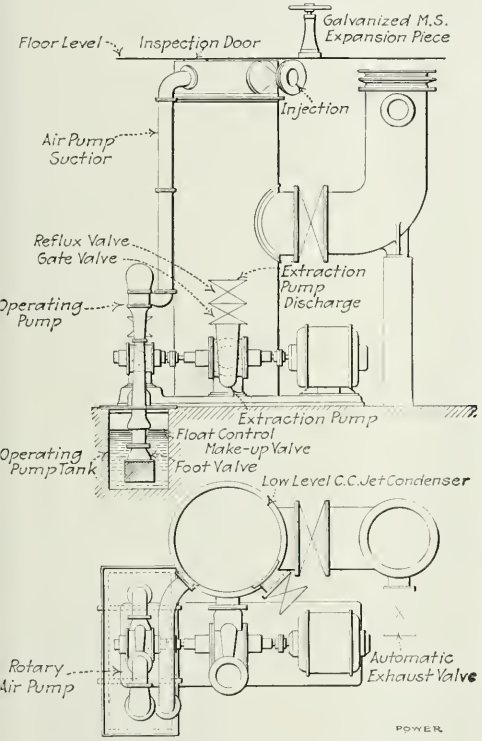


Fig. 3. Rotary Air Pump Connected to Jet Condenser

onsiderably, the vacuum will fall slightly and instantly ecover itself on a resumption of normal conditions.

Even if a serious leak should occur, causing the vac- um to fail, it will build up again immediately the leak s removed. This flexibility is because the air pump is ndependent of the operating pump on the vacuum side. A number of these machines have been installed to handle oads up to 45,000 lb. of steam per hr. with the vacuum anging from 27.5 to 28.5 in. under guarantee.

At the Newark Bay pumping station (Newark, N. J.) of he Passaic Valley sewerage district, three 100,000,000-gal. ubmerged centrifugal pumps are to be installed. The pumps vill be directly connected to engines, supplied with steam rom vertical internally fired boilers. The duty called for is 00,000,000 gal. per hr. against a 37-ft. head or 50,000,000 gal. gainst a 20-ft. head, and "at all rates between."

The Frahm Vibration Tachometer

Unlike most tachometers, the Frahm has no gears and is not made to register through outside-rotating connec- tions with the machine on which it is mounted. Instead an application of the principle of resonance is made by rigidly mounting one or more rows of tuned reeds side by side on a common base, Fig. 1. The reeds are made of spring steel about 3 mm. wide with the free ends bent over, as shown in the end elevation.

The instrument is mounted directly to the machine usually by solid iron brackets. Slight vibrations are set

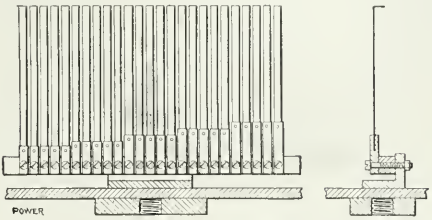


Fig. 1. How Indicating Reeds Are Mounted

up by the revolving element of the machine, which is never perfectly balanced. The number of vibrations depends upon the speed of rotation, and that reed in the instru- ment which is in tune with the vibrations will vibrate

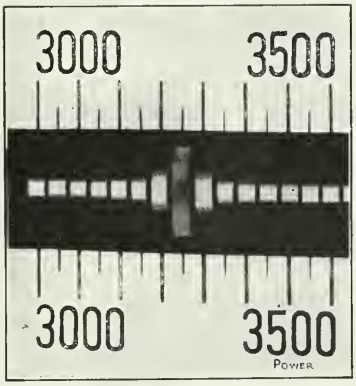


Fig. 2. Showing Vibration of Reed

through the action of resonance, thereby indicating the revolutions per minute of the machine. If, say, a turbine is making 3000 r.p.m., there will be 3000 impulses and the reed tuned for 3000 impulses will vibrate, thus in- dicating the speed. The interval between the reeds is usually from 1 to 2 per cent. of the maximum range so as to give accurate readings.

Fig. 2 shows a part of the graduated face of the in- strument. Notice the reed indicating a speed of 3250 r.p.m. Fig. 3 shows the appearance of the instrument.

The instrument is best suited for speeds ranging from 900 to 8000 r.p.m., being adapted to turbines, motors, centrifugal pumps, etc. Should the reeds vibrate ex- cessively, a piece of felt should be placed between the ma- chine and the supporting bracket.

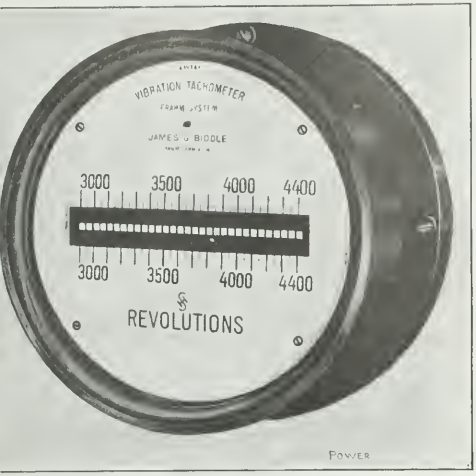


Fig. 3. The Frahm Vibration Tachometer

The vibrations set up by a turbine are indicative of the ndition of balance of the rotor. It would seem, there- re, that this instrument would show by the amplitude the vibration of the reeds whether or not the machine s in normal balance.

The Frahm tachometer is made by Siemens & Halske, rmany. James G. Biddle, 1211 to 1213 Arch St., iladelphia, is sole agent for the United States.

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New Kroeschell Boiler

The accompanying illustration is of the combination ter- and fire-tube boiler recently developed and pat- ted by the Kroeschell Brothers Co., Chicago, Ill., with shell and extending back about two-thirds of the length of the boiler.

The connection between the front water leg and the main shell is 10 to 12 in. in diameter through which the water flows with a high velocity.

A part of the rapidly moving stream of water entering the drum through the front connection, passes under the deflection plate, preventing any deposit of scale-forming material on the shell or tubes and causing such material to be carried to the sediment chamber in the rear water leg, whence it is readily discharged through the blowoff.

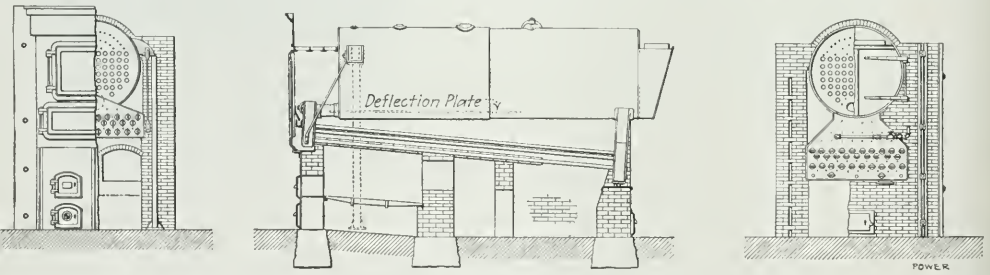
It is claimed that after a run of one of these boilers for four weeks in actual operation, there was found a deposit of less than one pint of sediment in the drum and this had settled on top of the deflection plate near its rear end.

Hollow stay-bolts are used with openings large enough to admit a flue blower, whereby accumulations of soot may be blown off the outside surfaces of the tubes at frequent intervals. A handhole plate is placed opposite each end of each tube for inspection and cleaning.

The furnace baffling is so arranged that the gases of combustion pass around the water tubes and under the shell of the boiler, returning through the fire tubes and passing out of the smoke box at the rear. This arrangement removes the lower half of the shell from the fierce impingement of the fire and still retains it as efficient heating surface. It also prevents unequal expansion and contraction between the tubes and the shell, thus preventing leaky tubes.

On account of the rapid circulation it is also claimed that this boiler gives an efficiency equal to a water-tube boiler as well as a high overload capacity and great flexibility.

Summed up, the points of merit claimed for this boiler are high efficiency; great overload capacity; rapid and positive circulation; self-cleaning of mud and sediment; accessibility; low draft resistance, which means good



The Kroeschell Combination Water-Tube and Fire-Tube Boiler

e idea of combining the advantages of both the water- be and the horizontal return-tubular boiler.

The boiler consists essentially of a return-tubular boiler which are attached two water legs; tubes are expanded o these water legs in straight horizontal rows with a vnward inclination toward the rear water leg of 1 in. the foot. Three or four rows of tubes are used, ac- rding to the size of the unit. Among the special fea- es are the connection between the front water leg and shell, and a deflection plate in the bottom of the shell, jecting into the connection between the water leg and combustion under ordinary or poor draft conditions; freedom from tube leakage and rapid steaming ability, which makes it well adapted to fluctuating loads.

⁂

Some machines need coaxing; some have to be forced to higher efficiency. Machines act very humanlike at times. A little higher or lower speed may increase the output. I've reduced a machine's speed and increased its average output. Machines must be matched with work and conditions just as men. Sixty warpers in a white-goods mill were operated for years with the creel, instead of the front of the machines toward the light. When they were faced in the opposite direction, the output was increased.—"Factory."

ELECTRICAL DEPARTMENT

Installation and Care of Storage Batteries—II

By H. M. Nichols

First Charge

The charging current should be ready to turn on as soon as the electrolyte is poured into the cells; otherwise the plates are liable to be injured by sulphating if allowed to stand in the acid without being charged. Have all connections made, cables run, etc., to avoid delay, and never under any circumstances allow the new plates to stand in the acid longer than two hours before beginning the charge. Care must be taken to see that the positive pole of the charging dynamo is connected to the positive pole of the battery as a reversal in connections would ruin the battery.

It is a good plan to test out the generator connections with a direct-current voltmeter and then make them permanent to avoid danger of their being accidentally changed. If at any time repair work is done on the generator or cables leading to the battery board, recheck the polarity, as there is always the possibility of reversal.

The first charge should be carried on for a period of 20 to 30 hours or even longer as this charge is necessary to complete the forming of the plates. The charging may be carried on at the normal rate, provided the temperature of the cells does not go above 100 deg. F. If the temperature goes above this point the charging current must be reduced. It is permissible to charge at a rate lower than normal for a correspondingly longer time if it happens to be more convenient to do so.

The normal rate of charge is usually marked on the cells by the manufacturers, but it may be found by dividing the ampere-hour rating by eight. Thus for a cell the rated capacity of which is 800 amp-hr., the normal charging rate would be 100 amp.

The voltage required at the beginning of the charge will be about two volts per cell and this will rise to a maximum of about 2.6 volts when the cells are fully charged. As the charging nears completion the cells will begin to gas freely, indicating that the plates have taken up nearly all the charge possible and that the surplus current is being used up in decomposing the electrolyte. At this point it is well to decrease the charging current, although moderate gassing does no particular harm other than waste energy.

When the cells are first filled with electrolyte the specific gravity will fall considerably below 1.200, due to absorption by the plates. The specific gravity will rise during the charge until it reaches slightly over 1.200 at full charge. During the ordinary operation of the cells the specific gravity when charged is about 0.025 higher than when discharged.

General Charging

Always charge at the normal rate or lower except in the case of emergencies. The longest life and highest efficiency is obtained when the battery is charged slowly. During the charge the voltage rises from about 1.8 volts per cell to approximately 2.5 volts when fully charged.

As the battery becomes fully charged, bubbles of gas will be given off freely, which will give the electrolyte the appearance of boiling. Sometimes these bubbles are so fine and numerous that they give the liquid a milky-white appearance. When the battery reaches this stage it is considered fully charged, although it can be made to take up a small additional charge by reducing the strength of the charging current.

The specific gravity of the electrolyte gives another valuable indication of the amount of charge held in the cell, but it is usual practice to depend principally on the voltmeter readings.

If the battery is allowed to remain idle for any length of time, it should be given a charge every week or two to compensate for the loss of charge due to current leakage. If the battery is allowed to stand much longer than two weeks without being freshly charged, there is great danger that the plates will be injured by sulphating.

Trouble is sometimes experienced from excessive acid spray. As the battery becomes nearly charged, the gas bubbles become so numerous that the electrolyte appears to boil and these bubbles breaking at the surface throw a fine spray of acid into the air. This spray corrodes all the metal fittings that it comes in contact with and is also very irritating to breath.

Various remedies have been tried, such as having a film of oil over the electrolyte which does away with the spray, but is objectionable because it sticks to the plates when they are removed, increasing their resistance when they are replaced. Another plan is to put glass covers over the tops of the cells, but they soon collect dust which forms a conducting surface for the leakage of current. The best plan is to reduce the charging current near the end of the charge and depend on good ventilation to remove what fumes are given off.

Discharging

In ordinary practice a battery is discharged within a few hours after it has been charged. Under these conditions the battery will deliver from 75 to 80 per cent. of the energy put in during charge. In some installations the battery is kept "floating" on the line so that it will take care of any heavy overloads and thus keep the line voltage from fluctuating. In this type of installation the battery carries a considerable percentage of full charge most of the time, as it is likely to be on discharge for only a few minutes at a time and then shift to charge as the load drops, and so on throughout the day.

If the battery is allowed to stand a week before discharging, there will be an additional loss of about 25 per cent. in efficiency.

The discharge rate in amperes is usually the same as the charging rate, which is found by dividing the ampere-hour rating by 8. The battery may be discharged at a

e considerably greater than the 8-hr. rate for a correndingly shorter time. In doing this, however, a cern percentage of the capacity in ampere-hours is wasted. r example, a cell whose 8-hr. discharge rate is 50 amp. y be discharged at the rate of 200 amp. for one hour, in doing this the cell suffers a loss of 50 per cent. in ampere-hour capacity. Excessive discharge rates are urious to most forms of cells and should be avoided. The types of cells that use pasted plates are the most ble to injury from this cause. A battery should never discharged below a voltage of 1.8 volts per cell, except the case of heavy discharge for short periods. If the tery is discharged at the one-hour rate, the voltage y be allowed to fall as low as 1.6 volts per cell. If this e is not observed the cell is very likely to be permatly injured.

Never allow the battery to stand discharged for more an two or three days, as, otherwise, its capacity is likely be considerably lessened by "sulphating."

Weekly Inspection

Once a week each cell in the battery should be carefully pected and tested. With the battery fully charged, asure the voltage of each cell with a low-reading voltter. For this purpose a pair of prick-point leads will found convenient. These are made by soldering a gth of flexible cable to a sharp spike which is driven o a wooden handle, the cable being brought out through hole drilled through the central axis of the handle.

With the battery fully charged also measure the specific avity of the electrolyte in each cell. In measuring the ecific gravity of the electrolyte, use a battery syringe draw a sample for test from the lower part of the l, as there is likely to be a slight difference in density ween the top and the bottom of the cell. A low specific avity or low voltage indicates trouble of some kind ich should be investigated and corrected at once. If y of the positive plates have a light color it indicates sufficient charge.

Examine the cells for short-circuits both external and ernal. When sufficient sediment collects in the bottom the cells to threaten a short-circuit, siphon off the ctrolyte, which may be used again and flush out the ls with clean water.

The electrolyte should be kept at least ½ in. above the ps of the plates. Any electrolyte that is spilled or dispated by acid spray should be replaced by electrolyte 1.200 specific gravity. Any loss due to evaporation ust be replaced by distilled water. When the cell is ly charged the specific gravity should be about 1.200. the hydrometer shows a lower figure when the voltage the cell and the color of the positive plates indicate l charge, dilute acid should be added to bring up the ecific gravity to 1.200. Never add strong acid directly the electrolyte in the cell.

If the specific gravity is too high add pure distilled ter to the bottom of the cell with a battery syringe or bber tube. It is necessary to add the water at the botn as it is lighter than the electrolyte and if it was ded at the top it would not mix well.

A record should be kept of the weekly inspection of the ttery so that a comparison can be made from week to ek of the action of each individual cell.

A convenient form for this record is given below.

STORAGE BATTERY INSPECTION RECORD

Station———— Date————

Cell No.	Volts Open Circuit	Specific Gravity	Remarks

Always take the record with the battery fully charged and also record the total battery voltage. Under the column headed "remarks," note any peculiar conditions of the cell and also any troubles corrected. Also record any additions of water or acid to the electrolyte to bring its specific gravity to the proper value.

Locating and Correcting Troubles

The most frequent troubles that occur in storage batteries are short-circuiting, sulphating, flaking, disintegrating of the plates, and buckling or warping of the plates.

Short-Circuiting

A short-circuit is indicated when the voltage and specific gravity are below normal. The short-circuit may be caused by sediment collecting in the bottom of the cell or by some foreign substance falling into the cell Cracked insulation may also cause a partial short-circuit

A cell that has been short-circuited will require more than its usual amount of charge for some little time. This can be accomplished by charging the cell as usual but cutting it out of circuit for several discharges. This method is only practical with small cells that are connected together with bolt connectors. Another plan that does not require the disconnecting of the cell under treatment is to give it an additional charge from an outside source after the battery has been fully charged. Temporary leads can be run to the defective cell for this purpose.

Sulphating

A cell is said to be sulphated when a whitish scale of lead sulphate forms on the plates. This scale is a nonconductor and thus serves to insulate the active material from the plates. Any indications of sulphating should be corrected at once, for if it is allowed to continue it will not only greatly reduce the capacity of the battery but will also lead to other serious troubles.

Sulphating may be caused by overdischarging, or the battery may be left in a discharged condition for several days, even if the limit of discharge has not been exceeded. If the electrolyte is allowed to get too hot (due to an excessive discharge rate) or if it is too strong the plates are likely to sulphate. A short-circuit may also cause sulphating by discharging the cell below its proper voltage.

A cell that is badly sulphated should have the plates removed and carefully scraped until all traces of the scale have been removed. The cell should then be charged at a low rate (from one-quarter to one-half the normal rate) and only partially discharged. This treatment should be

continued until the sulphating is entirely eliminated and the cell returns to its normal condition.

In some instances it is a good plan to add a small quantity of sodium carbonate to the electrolyte, which will help to dissolve the objectionable scale. After the scale has been removed the electrolyte should be thrown out, and the plates carefully washed to remove all traces of the soda.

Flaking, Disintegrating and Buckling of the Plates

If the plates are allowed to become badly sulphated, the final result will be that the active material will peel off in large flakes. Buckling is caused by sulphate working in between the active material and the supporting grid. Flaking and buckling are also caused by excessive discharge rates and sometimes by long continued overcharge.

Flaking is objectionable because it reduces the capacity of the cell, due to the loss of active material. Buckling is likely to break up the pellets of active material and cause them to drop out.

Sometimes a plate that has begun to buckle can be straightened by putting it between two soft pine boards and pounding on them gently with a wooden mallet, taking care not to disturb the active material. Positive plates are more likely to be injured from any of these troubles, and it is to them that particular attention should be given.

Taking the Battery Out of Service

In many installations, such as country residences, summer hotels, etc., the storage battery is allowed to lie idle for a period of several months. In installations of this type the storage battery should be taken out of service at the end of the season.

This is accomplished by first discharging the battery fully at the normal rate, then siphoning the electrolyte into clean carboys for future use, and filling each cell as soon as it is emptied with pure water. When the electrolyte has been replaced with water in all the cells, the battery should be discharged until the voltage falls below one volt per cell with normal current flowing. When this condition is reached the water should be siphoned off. The plates may be left in the cells or they may be removed and packed away for storage. When it is desired to put the battery in service again, proceed as when the battery was first started, giving it an initial charge of from 20 to 30 hr. at the normal rate.

A New Primary Cell

By Dr. Leonard K. Hirshberg

A. J. Paine, of Wanstead, Eng., has just invented a simple element for generating current that yields 1½ volts for 12 hr. He was in need of a primary cell which, as he put it, would "go one better than the ordinary well known cell," and after making a long search, ultimately came to this combination.

He recognized that chloride of iron had been previously used in cells as depolarizers, but considered no such cells satisfactory either as to capacity or durability. He, therefore, adopted a zinc-carbon excitant with chloride of iron around the carbon and a saturated solution of sodium hyposulphite around the zinc. This gave 1½ volts with a very low resistance. Four cells that each held a quart gave 2 amp. and 6 volts which lasted 11¾ hr. when a slight decrease in current began. The current remained constant as long as the chloride of iron was saturated.

The carbons can be made of a gridiron series of plates with lumps of the iron chloride on top. Plain zinc is better than analgamated zinc. If a black scum forms after 11 hr., a little running water will remove it. There is no odor at all to the Paine cell. Hyposulphite of soda is twice as efficient, according to the inventor, as zinc sulphate or other zinc solutions.

Troubles with a Second-Hand Dynamo

Buying second-hand electrical machinery is largely a gamble. In the present instance a four-pole, 25-kw., 110-volt dynamo was purchased from a reliable dealer on a guarantee to be in good running order and to develop the rated load when running at 625 r.p.m.

The machine was set up and started, but would not show more than four volts by the voltmeter. Short-circuiting the armature would only raise the voltage temporarily, its value dropping back as soon as the short-circuit was removed.

A careful examination of the machine and the armature winding showed the direction of rotation to be right, but it was almost impossible, owing to the taped insulation to tell the direction of the shunt-coil winding.

There were no marks to indicate which were the positive or negative terminals and the position of the brushes was all one had as a guide. After tracing the winding it was discovered that the wires leading to the rheostat were both connected to the same side.

To rectify this mistake, which had made the magnetizing effect of the shunt coil almost nil, one wire was changed to the opposite side which made the shunt coil active, and the machine immediately built up the voltage, but would not carry more than half load without lowering the voltage. This was due to the fact that the shunt-field coil and the series coil were opposing one another. The series coil was a very small one and its effect on light loads was not appreciable, but when heavy loads came on, its effect was greater and the heavier the load the less the voltage. Suspecting this to be the cause of the low voltage as soon as it was possible to stop the machine, I shifted the leads of the series coil. This left the electromotive force flowing through both the series and shunt coils in the same direction and the machine then held up the voltage as required.

R. A. Cultra.

Cambridge, Mass.

The quantity of coal required to produce a ton of coke is much less than formerly. The average gain in 1912 compared with 10 years ago is probably at least 160 pounds. It is doubtful if in the earlier years the actual yield of coal in coke exceeded 60 per cent. whereas in 1912 it was 67 per cent., according to the United States Geological Survey. This gain is largely due to the increase in the production of by-product coke, in which the yield of coke from a ton of coal is very much higher than in making beehive coke. In Illinois, Indiana, Massachusetts, Michigan, New Jersey, New York, and Wisconsin, where coke is made exclusively in by-product plants, the yield varies from 69.6 per cent. (in Wisconsin) to 81.8 per cent. (in Indiana), whereas in the States where beehive practice prevails the yield in 1912 varied from 50 per cent. (in Georgia) to 66.5 per cent. (in Pennsylvania).

GAS POWER DEPARTMENT

The Big Ford Gas Engine

By F. R. Low

When the ordinary man lays out a manufacturing establishment he puts the power plant in the back yard if not in the cellar. Henry Ford is not an ordinary man, and when he built the Ford works in Detroit he put the power plant in a glass case and set it out upon the sidewalk. Fig. 1 shows how it looks to the passerby on busy Woodward Ave.

Fig. 1. Power House from Street

For an ordinary plant the ordinary man would have selected the "safe and sane" steam engine. When the Ford plant was built the producer-gas engine was at the front in the power field, and Ford adopted it and has held to it through all the vicissitudes which have assailed the big gas-engine business. When the company from which the first engine was bought was unable to carry out its contract he completed it himself. With that engine he got Edward Gray, and whether they made the engine go where so many have failed may be judged from the fact that they are today installing, built to Mr. Gray's design, the most powerful producer-gas engine yet built in any country.

The first unit installed was a 35x48-in., two-cylinder tandem running at 100 r.p.m. It drives an 850-kw. Western Electric generator and a 2000-cu.ft. air compressor, to which it is cross-connected, and develops only about one-quarter of the power which the works at present demand. Fig. 2 shows this unit, which is of the Riverside type, described in detail in our issue of May 5, 1908.

The building, originally large enough to accommodate this unit only, has been extended to receive the new large engine, photographs of which are reproduced in Figs. 3 and 4. It was built at Hamilton, Ohio, by the Hooven,

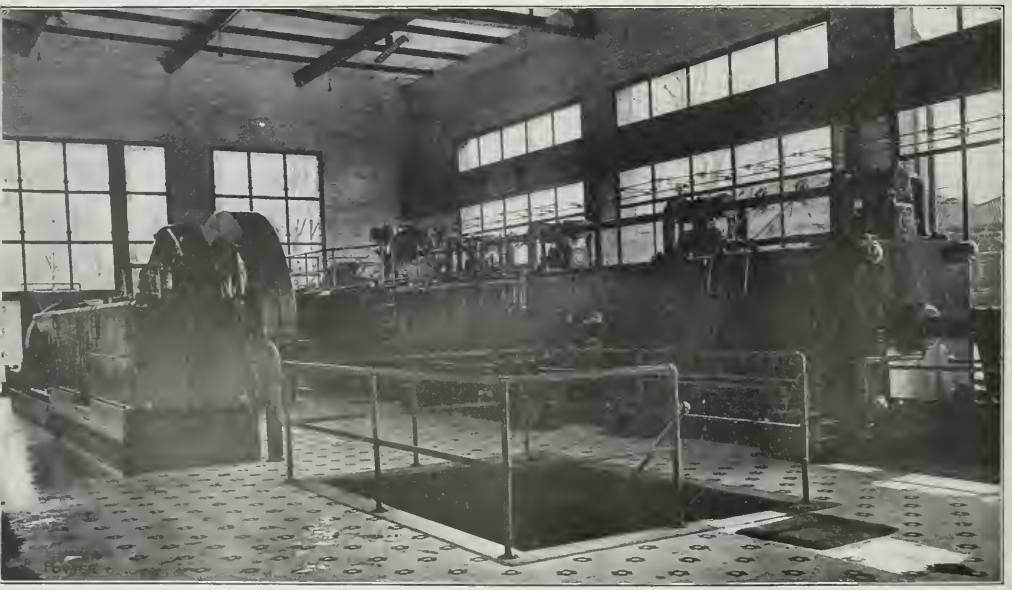


Fig. 2. General View of Smaller Engine

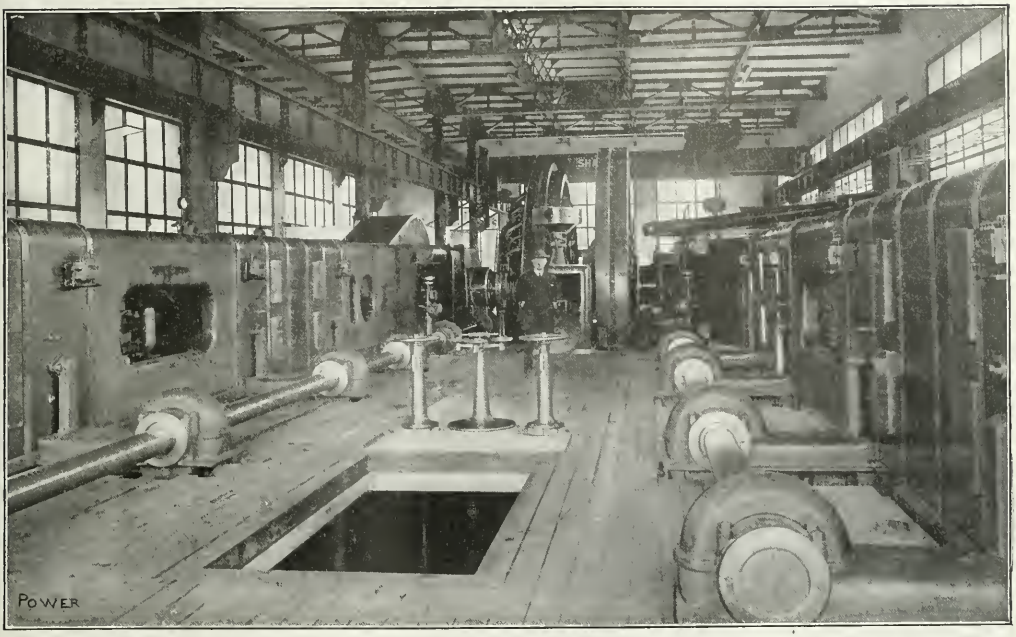


FIG. 3. BIG FORD ENGINE FROM HEAD END

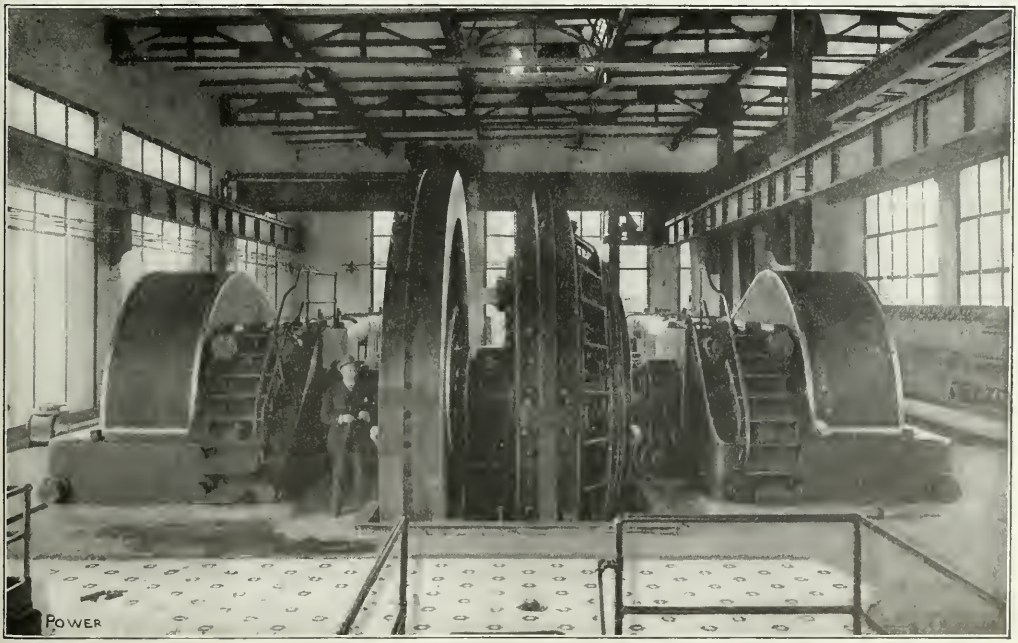


FIG. 4. BIG FORD ENGINE FROM GENERATOR END

ens, Rentschler Co., and we hope in a future issue to ible to describe it more in detail.

The engine casting is designed symmetrically around center line. There is no massive bedplate. The mo- of the designer was not to bind his engine together great masses and then torture them with conflicting sses, due in part to their own massiveness, but to l the cylinders in line upon an ample foundation with dom to come and go under stress and temperature, with plenty of metal to take the working stress and igidly preserve alignment and relative position where are essential. The weight is, therefore, carried di- ly by the foundation with light sole plates and guides he places where movement will take place.

This is a one-story and basement engine, and the valve- r is all in the basement; see Fig. 6. There are four ble-acting cylinders, 42x72 in., two in tandem upon n side, held together with four 6-in. tie-bolts. The ine is designed to run at 85 r.p.m., or 1020 ft. of pis- speed. There have been gas-engine cylinders of tter diameter, but this length of stroke and piston

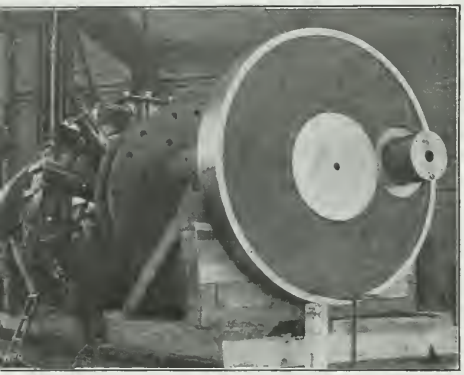


Fig. 5. Crankshaft and Crank

ed give, we think, the greatest displacement that has been attained per cylinder.

The length of the engine from the front of the pillow k to the end of the tail-rod extension is 73 ft. and overall width is 32 ft. The crankshaft (Fig. 5) is n. in diameter, 25 ft. long, carrying an 80-ton flywheel a 2500-kw. generator armature, and the connect- rods weigh 10,300 lb. each. The generator is capable carrying a 25 per cent. overload, and the engine has apacity of 5000 i.hp.

The layshafts are driven by bronze worms upon the n shaft, and are divided by pin couplings, so that expansion takes place, each section remains with its ticular cylinder and the crank *B* preserves its align- nt with the rocker-arm *A*, Fig. 7, which it drives. Each shaft carries four cranks, one for each end of each nder, and each crank operates both the inlet and the aust valve of the end which it serves.

Both of these valves are of the mushroom type and are ted in the pockets in the bottom of the cylinder. The aust port is visible in the bottom of the cylinder, Fig. The crank rod takes hold of the rocker-arm, which is nected by a right and left connection to the exhaust- valve wiper *B*. This is shown in its active position in Fig. 6. In this position a small movement of the rocking lever will produce a considerable movement of the wiper and communicate a quick movement to the valve, while in Fig. 7 the wiper is shown in its position of dwell

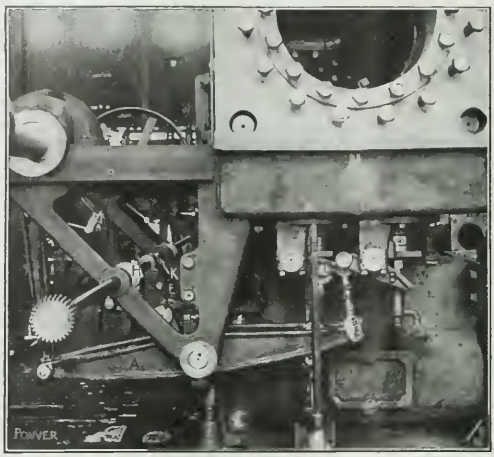


Fig. 6. Valve-Gear with Exhaust Valve Just Being Raised

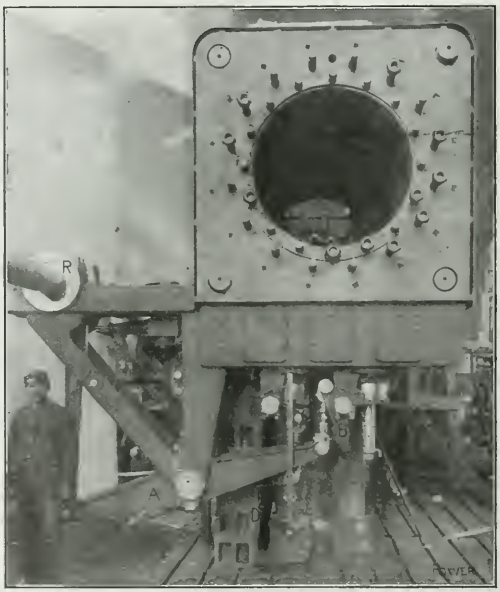


Fig. 7. Valve-Gear with Exhaust-Valve Wiper in Position of Dwell

where the rocker-arm, and especially the crank, which is near the bottom of its throw, can move through a considerable arc without moving the valve.

It will be noticed that the rocker-arm or beam is double, and that the connections are through pins, with

no overhung bearings, a principle which is carried throughout the design.

The admission valve is actuated by a wiper C driven by the lever D (Fig. 7), carried between the arms of the beam and pivoted at the center. The hook E carried upon a lever pivoted in lugs upon the rocker-arm, engages with a similar block upon the arm F (Fig. 6) which forms a bell crank with the lever D, lifting that lever and with it the wiper C, which actuates the inlet valve. A cam, the position of which is controlled by the eccentric H upon the governor shaft K, trips the valve at a point in the stroke determined by the governor, just as the steam valve upon a Corliss engine is tripped, and the valve is closed by a spring (not shown) and cushioned by the cushion pot L. The governing is thus by the quantitative method, and the governor, which is of the Jahns type, has no other work to perform than to adjust one position of the tripping cams. Motion is taken off from the crank rod by the lever M for the positive feed lubricators. The entire gear is direct-acting, simple and accessible.

Water for cooling the pistons is taken in at the crosshead between the two cylinders through the telescopic rod R (Fig. 8). The lower end is pivoted below the engine and the rod oscillates with the crosshead. The piston rod contains an inner tube through which the water passes to the piston; on the return it passes outside this inner tube and thus raises the temperature of the incoming water.

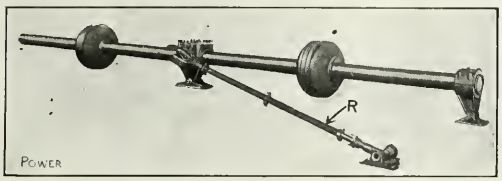


FIG. 8. ARRANGEMENT FOR SUPPLYING WATER TO PISTONS

Silencer for Large Engines

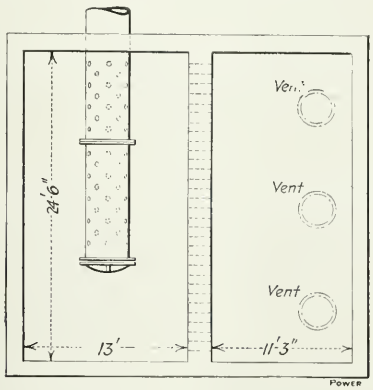
In a large engineering works where gas generated from bituminous coal was the motive power, the silencer here described was constructed for one of the power houses to handle the exhaust gases from engines of a total of 2500 hp., although at first only one engine of 1000 hp. was installed.

The silencer was built just outside the power house, and consists of a brick-lined pit divided into two chambers, as shown in the sketch, which is a plan view with the top removed. This top consists of I-beams, between which is cement, supported by wrought-iron plates resting on the lower flanges of the I-beams. There also are manholes for the two chambers.

The chamber into which the exhaust pipe enters is 13 ft. wide, 24 ft. 6 in. long and 7 ft. 6 in. deep, with a volume of 2389 cu.ft. This is separated from the second chamber by a perforated brick wall. The second chamber is 11 ft. 3 in. wide, 24 ft. 6 in. long and 7 ft. 6 in. deep, with a volume of 2067 cu.ft.

The cast-iron exhaust pipe entering the first chamber is close to the ground, and has an internal diameter of 3 ft. 4½ in., giving an area of 1288.2 sq.in. The lower half of the pipe is perforated, the first length by 2¼-in. holes, pitched 8 in. from one another in lines parallel to the center line of the pipe, and staggered from the next row, the rows being spaced 4⅝ in. apart. The area of the perforations in this length is 1119 sq.in. The second length of pipe is perforated by 2⅜-in. holes similarly spaced, giving an area of 1230 sq.in. At the outlet end of the pipe is a blank flange.

On the top of the second chamber are three steel vent stacks, each 3 ft. 1¼ in. internal diameter and 55 ft. high. The exhaust gases after leaving the engine pass through a water heater, or when the heater is cut out, through a grid of iron plates played on by a spray of water, before entering the silencer.



PLAN OF EXHAUST PIT

G. MOORE.

Newark, N. J.

Another Hamburg-American Liner with Diesel Engines

From the shipyard of Blohm & Voss, Hamburg, has been launched the motor cargo vessel "Kurmark" for the Hamburg-American Line. This vessel is of 7500 tons gross displacement and will be provided with two single-acting, four-cylinder, two-stroke cycle, Diesel engines developing a total of 2700 b.hp.

Two four-cylinder, four-stroke-cycle auxiliary engines, each driving a dynamo, are provided; one of the engines also drives an injection air compressor, and the other a manoeuvring air compressor. The compressors can be disconnected. A small two-cylinder set, driving a dynamo and an auxiliary compressor, serves as a standby. When at sea the main engines themselves effect the operations necessary for their working. One of the four-cylinder auxiliary sets supplies, when running at a moderate speed (about 250 r.p.m.), the electricity for lighting the interior of the ship and for driving the steering gear, ballast pumps, lathe and reserve auxiliary pump. The other auxiliary engine forms a reserve. Cooling-water pumps, bilge pumps, etc., are driven from the main engines. The small reserve set generates the current for lighting when in port.—*Der Oelmotor.*

REFRIGERATION DEPARTMENT

Causes for Variation in Quality of Distilled-Water Ice

By Peter Neff

It is apparent to all that there is a great variety in the quality of distilled-water ice, some plants produce a superior grade while others in the same locality do not. Why this is so may be due to a multitude of causes. There are, however, several simple ones which to a greater or less degree affect the quality, and some of these will be considered.

If pure distilled water could be placed in the cans, the ice would be practically clear and of a uniform quality. This condition cannot be realized in practice and all that can be hoped for is to approximate the ideal condition as nearly as possible.

Air in the water is an ever present trouble. If it has not gotten into the water before, it will when the can is being filled. The amount will vary with different tank men, because intentionally or otherwise, one man will so place the can and filler that a minimum amount of water will seal the end of the filler. Where the storage tank is placed so high above the top of the ice tank that there is considerable pressure at the filler, the inrush of the water to the can when the filler is opened will cause a large amount of air to be taken up by the water. This can be avoided by choking the flow to the can-filler hose.

A frequent source of air introduction is produced by draining the storage tank so low that the outlet is exposed, or so nearly so as to cause a suction of the air. There are times when the packing about the stem of the can-filler valve is not tight. When not in use a small leak may be observed at this point, which usually disappears when the filler is put into service, for the water in passing this opening will cause air to be drawn in.

The most fruitful source of air is the flat cooler, and sometimes the filter as well, when located above the storage tank. In such an arrangement there is a tendency at all times to suck in air through small leaks about the valve stems and joints. By putting water pressure on this part of the apparatus, the leaks may be located. All parts of the distilling system from the reboiler or skimmer to the storage tank should at all times be full of water under pressure.

Where the condition noted prevails, a regulating valve controlled from the reboiler or skimmer should be placed at a point below the bottom of the storage tank. And the opening through this regulator should not be so great as to allow the water to flow through faster than supplied from the reboiler or skimmer, for if it does it will produce a suction on the apparatus between the regulator and the reboiler.

Care must always be exercised to see that the reboiler is not allowed to drain, for when it does enough air is introduced to ruin all the water in the storage tank and in some cases to cause parts of the apparatus to become air-bound. The surest method is to have the flat cooler and filter below the bottom of the storage tank, which will insure their being full of water at all times, but even then it is desirable to have the regulator below the storage tank.

A little care in these particulars, remembering that falling water will suck in air when passing a small opening, will reduce air troubles to a minimum.

Air in the water is manifested in the ice by a white core with radiating needles. But air is not the only cause of white ice. Other gases generated in the boiler from impurities contained in the water used, pass with the steam and are taken up by the water when condensation takes place. Some of these gases have a disagreeable odor, so often noticeable in manufactured ice. A proper venting of the steam condenser will help to get rid of these gases. In other words, allow a small amount of steam to escape from the condenser at all times.

The object of the reboiler is to further eliminate these gases as well as the air, and for that reason the reboiler does better work when the depth of the water is small in comparison with the area of the water surface, so that the gases have a freer exit. In spite of these precautions some gas will remain in the water, and for this reason it is customary to filter the water through charcoal, taking advantage of its peculiar property to retain or occlude them. The capacity of charcoal for this purpose is limited, especially when some oil is passing with the water, as the oil tends to fill up the small interstices in the charcoal. When care is not exercised to thoroughly eliminate these gases in the condenser and reboiler, it is but a short time before the charcoal filter is of no use, although to the eye the charcoal may appear all right.

Of all these gases the principal source is the foreign matter contained in the water used in the boiler. Some gas may come from the oil used, but the greater quantity comes from the water. As the process of concentration goes on in the boiler, more of these gases are driven off, and the higher the temperature of the steam, corresponding to a higher pressure, the more readily will the gases be formed. To obviate this trouble, the boilers should be blown down frequently, and the steam pressure carried no higher than is necessary for the work and supply only the requisite amount of distilled water.

There is another trouble causing white cores and sometimes a white or cloudy appearance of the outside of the cake of ice, with clear ice lying just under it. This trouble also comes from impurities in the water used in the boiler. More or less water is carried along with the steam, and if the boiler is priming the quantity may be considerable. When this raw water contains certain impurities, they crystalize at the same time as the ice crystals are formed, and produce the cloudy appearance referred to, which is easily distinguished from the white ice produced by air. Other impurities concentrate in the center of the ice cake and go to make up the white core. A separator on the main steam line will help eliminate this trouble, which is also lessened by the frequent blowing down of the boiler.

There is the question of iron rust from the interior of the apparatus, the troubles caused by the presence of oil, dirt and bacteria, and sometimes raw water getting into the ice can from the fact that the cans after being in a dip tank are not drained. This trouble has been one of the reasons why can dumps that return the can to an upright position as soon as the ice goes out, have not been popular. To guard against these troubles, as well as many others in different parts of a plant, is the daily consideration of a good engineer. It is a fight all the time and success will come only to the engineer who will use his head, and is quick to detect small irregularities in the operation of the plant.

Operating on the Flooded System

By R. L. Mossman

Some of the advantages of the flooded system over the expansion evaporating system will be mentioned for the benefit of engineers who have not handled both. The flooded system is used to supply each and every coil in the freezing tanks with a proper supply of liquid ammonia. The distribution of the liquid is practically automatic, due to the head of the liquid carried in the accumulator above the brine-cooling coils. To properly regulate the supply of liquid to each coil is more difficult when the expansion evaporating system is used for the reason that it is hard to tell which coil is getting too much and which

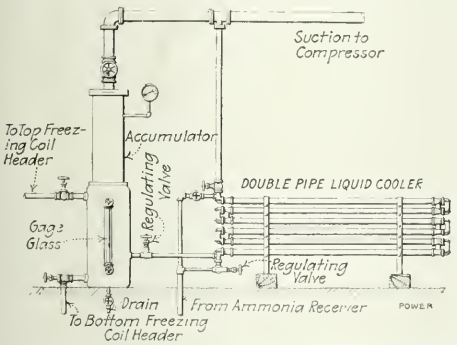


Fig. 1. Flooded System with Double-Pipe Forecooler

is getting too little liquid. In a plate ice-making system the necessary supply of ammonia to each plate becomes less as the thickness of the ice increases, making it necessary when separate expansion valves are used for each plate, to adjust the regulating valve frequently. The flooded system takes care of this variation automatically.

To get the best efficiency in the operation of cooling coils their internal surfaces should be kept wet by the liquid at all times. The pipes which are filled with vapor do very little work. The flow of heat from the brine is much greater when there is liquid than when there is gas on the inside of the pipes. The truth of this statement can be verified by observing the evaporation of a sample of ammonia in a test tube. No ice will be formed on the outside of the tube above the surface which is wetted by the liquid. A similar action takes place in the coils of the freezing tank.

In the flooded system liquid ammonia is fed into the bottom of the coils, and passes up through them to the accumulator from which it started. Here the vapor that has been formed is separated from the liquid, the vapor going to the suction of the compressor, while the liquid mixes with the fresh liquid introduced into the accumulator.

In the direct-expansion system the liquid ammonia is fed directly into the evaporating coils, and must be cooled

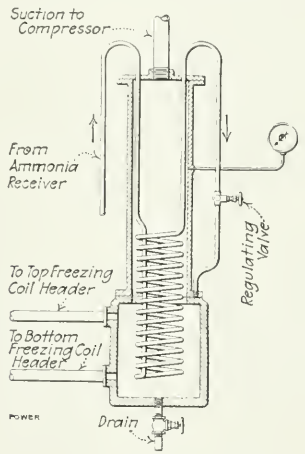


Fig. 2. Accumulator with Cooling Coil Inside

down to the temperature due to the pressure within the system before it can refrigerate the brine. This work of cooling down the liquid ammonia usually requires the evaporation of about 15 per cent. of the total liquid fed into the system. In the flooded system this work is done in the accumulator, the gas liberated going to the compressor while the liquid enters the coils.

While on this subject it will be well to mention that the practice in some plants of placing the ammonia receiver in the engine room or some other hot place should be condemned. The receiver should be placed in as cool a place as possible. Otherwise, if it is subjected to a temperature higher than the temperature due to the condensing pressure, it will absorb heat and some of it will evaporate and force vapor back to the condenser. Every 5 deg. that the liquid ammonia is cooled before it reaches the regulating valves means a reduction of about 1 per cent. in the work to be done by the compressor.

As an example, if the condensing pressure is 183 lb., the temperature of the liquid ammonia leaving the condenser will be about 90 deg. If the liquid is cooled down to 60 deg. by cooling water of about 51 to 56 deg., this reduction of 30 deg. in the temperature of the liquid before it reaches the regulating valve, means that the amount of ammonia that the compressor must handle to produce a ton of ice will be reduced 6 per cent. The capacity of the refrigerating machines for manufacturing ice will be increased one ton in every 17 tons.

Figs. 1, 2 and 3 show some of the accumulators and their connections that are in use with the flooded system. Fig. 1 shows the connections for a flooded system where a cooler is used to cool the liquid ammonia before it enters the accumulator. The ammonia from the re-

ceiver enters the inside pipe of the double-pipe cooler at the top and flows out at the bottom into the accumulator and out of the lower connection of the accumulator to the freezing coils, returning through the upper connection. The liquid is retained in the accumulator while the vapor goes to the suction of the compressor. The height of the liquid should be kept between the top and bottom connections. The liquid is cooled in the double-pipe apparatus by operating the regulating valve at the bottom of the cooler. The gas from the cooler is piped into the suction line as shown.

Fig. 2 shows a type of accumulator with a liquid fore-cooling coil inside. The liquid ammonia from the receiver passed through this coil and is cooled by the surrounding liquid and saturated vapor.

Fig. 3 shows another type of accumulator. Here the liquid ammonia enters the bottom of the freezing coils direct from the receiver or liquid cooler, if one is used. The amount of liquid carried in the accumulator should be from 18 to 24 in., the height of the liquid being indicated by the frost on the small indicator pipe shown. The valve A at the top of the pipe should be only partly opened, just enough to equalize the pressure, for if it is opened too wide there may be enough expansion in the pipe to cause the frost line to show higher than the liquid

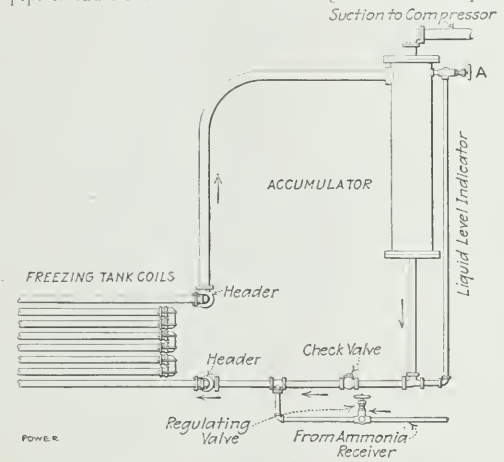


Fig. 3. Flooded System in Which Ammonia First Enters Tank Coils

level in the accumulator. As may be noticed there is a check valve on the bottom connection from the accumulator to the freezing coils to prevent any vapor from returning against the flow of liquid. All of the vapor has to pass out through the top connection of the coils.

In the flooded system the accumulator must always be placed higher than the freezing coils to give a head to the liquid, and all pipe lines slope toward the coils.

The following data show the approximate amount of ammonia required for different-sized plants using the direct-expansion and flooded systems:

Capacity, ice making, tons	Ammonia for direct-expansion system, lb.	Ammonia for flooded system, lb.
10	400	700
15	500	800
20	600	1100
30	900	1500
40	1200	2000
50	1500	2500

When the capacity of the plant is over 50 tons, the amount of ammonia required will be in direct proportion. For example, 100 tons would require 3000 and 5000 lb. of ammonia respectively. It would be possible to use less ammonia than the weights given.

Dead Ammonia

One of our readers recently asked if there was such a thing as dead ammonia and how it would act in a direct-expansion system. As there may be others who are not familiar with this term, we are publishing the answer as a matter of general interest.

The term "dead ammonia" is frequently applied to anhydrous ammonia that has become contaminated by refrigerating oil or perhaps water drawn into the system. The effect of these impurities is to raise the boiling point of the ammonia so that it is sluggish in evaporating out of the impurities at the usual back pressure.

By drawing a sample of such impure ammonia from a pipe coil or storage tank it will be found that when evaporation ceases the impurities will have deposited in the vessel used for the purpose. This is a good way to determine how much the ammonia has been adulterated.

There are, of course, ammonia purifiers on the market into which the impure liquids, generally found at the bottom of the receiver, are drawn. By means of a small amount of steam this liquid can be heated and the anhydrous ammonia returned into the suction line. The impurities are collected in the purifier and may be blown off. Another type of purifier not only takes the liquid from the receiver but also purifies the suction gas before it enters the compressor. Both systems are useful in connection with refrigerating and ice-making plants as they will eliminate the so called dead ammonia.

Cold-Storage Temperatures

The following cold-storage temperatures for different classes of goods were given by the committee on refrigeration of the National Electric Light Association:

	Deg. F.	Specific Heat
Beef (fresh)	36–40	0.68
Hogs	29–32	0.51
Lamb and mutton	32–36	0.67
Veal	34–36	0.70
Meats (in pickle or brine)	35–40	0.54–0.58
Butter	0–38	0.64
Eggs	29–32	0.76
Cheese	32–34	0.64
Lard	38–40	....
Poultry (to freeze)	5–10	0.78
Poultry (when frozen)	25–28	....
Game (to freeze)	5–10	0.80
Game (when frozen)	25–28	....
Fish	25–28	0.82
Oysters	33–45	0.84
Beer	33–42	0.90
Wines	40–45	0.90
Cider	30–40	0.90
Fruits	33–36	0.92
Vegetables	34–40	0.91
Canned goods	38–40	....
Flour and meal	40	....
Furs	25–32	....
Brine for ice cream freezing	5–10	....
Ice cream (air hardening)	5	....
Ice cream (serving temperature)	14–16	....

Mechanical refrigeration as applied to cooling water and milk usually has one feature different from other classes of refrigerating work. A large quantity of cooling effect is called for in a brief interval of time. For instance, in a drinking-water system the heaviest requirements may come at the noon hour. In dairy work the milk must be cooled rapidly to check the development of bacteria.

EDITORIALS

Large Units

The present is often referred to as an age of big things. Not only does each year bring forth taller buildings and steamships of more gigantic proportions, but in the power field the same tendency prevails—the adoption of large units.

Elsewhere in this issue are illustrated a few of the largest units of their kind. This list is by no means complete, for it does not include the big Delray boilers nor the thirty-five thousand-horsepower turbine which is nearing completion for the Commonwealth Edison Company of Chicago.

When such large units were first laid down there were many engineers who questioned their feasibility, both from an operative and an economic standpoint; in short, they did not believe in putting too many eggs in one basket. These fears have been discredited, however, by the subsequent performance of these large units; not only have they shown exceptional economy, but their operation appears to be entirely satisfactory. In fact, the Detroit Edison Co. was so well satisfied with the large Stirling boilers that it is increasing the number to nine at its Delray station, and the New York Edison Co. appears to have signified its approval of the twenty thousand-kilowatt turbines installed at the Waterside station by putting in still larger ones at its new station at Two Hundred and First Street.

In the gas-power field the big Ford engine, described on page 128, marks the present limit in size. How far this will be exceeded in the near future will no doubt depend to some extent upon the performance of this engine. While structural features will prevent the gas engine from catching up with the steam turbine in the matter of capacity, it is, nevertheless, more than holding its own, as evinced not only by the Ford engine, but from the fact that both the United States Steel Corporation's plant at Gary, Ind., and the plant of the Maryland Steel Co., at Sparrows Point, Md., are putting in a number of large gas engines.

The Fireman's Work

A dollar saved in the boiler room should mean more to the engineer or the man who pays the bills than a saving at any other place in the plant. With a given quantity of coal it means more steam and consequently greater initial energy to begin with. In the engine room, as much as possible of this energy is utilized, but the boiler is the source and any effort that may be made to increase its economical production benefits the plant twofold.

Admitting that this is true, and most of us will, it would seem that the position of the fireman in the power plant is one of the utmost importance. The engine room may contain units of the latest type, operating under a high vacuum and a load factor approaching unity, the steam pipes may be thoroughly covered and every detail arranged for maximum economy, yet the saving that all these refinements might effect would only be a small percentage of what the skillful fireman could do in the boiler room.

Dipping water from one barrel to another with a strainer is not an economical method. The second barrel may be tight and hold all the water it receives, but the loss in the initial supply would be enormous. A dipper is needed, and in the power plant this is an expert fireman. That such men are available in all that the name implies is being realized, but, unfortunately, there are many "strainers." There are firemen who measure their ability by the tons of coal shoveled per day, who know very little about the quantity of air required, and nothing at all about combustion and the possibilities of flue-gas analysis. Even the subject of draft, ordinarily so simple and all important, is apparently given little attention by the man who cannot or will not be a fireman.

There is nothing intricate about a draft gage. It is easily read and if these readings are properly interpreted they will serve as an excellent guide to the best method of firing and the proper intervals between. They will tell the uptodate fireman the condition of his fires from one cleaning to the next. They will tell him how much coal he can expect to burn per square foot of grate surface and, therefore, tell him how much steam the boiler will supply.

A case came under our notice where an economizer was installed. Ordinarily a saving in the vicinity of ten per cent. is credited to this apparatus. In this particular plant, however, the fireman admitted so much air to the furnace that there was very little left for the economizer to do.

In another case the draft in the furnace proved to be insufficient. The plant was loaded down to the limit. More steam was needed and it was impossible to burn any more coal on the grates. A new boiler was recommended but before the purchase a thorough investigation was made. The stack was found to be of the right height and diameter, the boilers were clean and apparently neither the baffling nor the damper interfered with the passing of the gases. Two right-angled turns in the breeching proved to be the cause of the trouble. An obstruction at the time of installation was the reason given, but this had long been removed and the tortuous path of the breeching had never been straightened. With this defect remedied more air was supplied, the combustion was better, and enough steam was generated to meet the demand.

If the fireman had used his draft gage the cause would have been revealed and it is likely that he would have noticed the defect in the breeching. He was shoveling all the coal that the furnaces would burn and naturally he thought that he had reached the capacity of the plant.

Many other cases of a similar nature exist. Thousands of dollars are needlessly wasted in the course of years, and all through neglect of a device so simple as the draft gage If failure to realize its importance is

the excuse offered, it is high time for the fireman to get busy. He must realize that he is an important factor in the plant and that its overall economy depends more upon him than any other man. In short, it is up to him to learn his trade so thoroughly that he will be recognized as an expert on combustion rather than a shoveler of coal.

⁂

Steam Power in Gas Works

It would seem that the phenomenal progress made in methods of operating steam boilers in very recent years would be evidenced in the boiler houses of every industry, but such is not the case. In various kinds of manufacturing plants one still finds the attention of the management concentrated almost solely on the production end of the business, while the power end is left to get along in the same old way, giving the same old service—unforgivably wasteful, but continuous, if "nursed" constantly.

An industry that was (some would say is) slow to take advantage of the improvements in boiler operation is that of illuminating-gas generation and distribution. The product of a gas works is gas, and generators, blowers, purifiers and candlepower are worthy of a gasman's consideration, but steam boilers are objects to be scorned. Such was and is the attitude of many men who have been "brought up" in the illuminating-gas business.

Several years ago if one had suggested to the average gas man that he plot curves and otherwise record the performances of the steam end of his plant, he would have regarded the suggester as one of those demagogues of technics who make life so miserable for many practical men. Yet there are now gas works the steam end of which is conducted according to the most modern methods, where complete record systems prevail and where experiments are being made to determine the advantages and disadvantages of this or that method of accomplishing a given result. In short, there are now many gas works where as much attention is being paid to the steam end as is devoted to the generation of the gas.

Those familiar with gas works know that for years the tar, a byproduct, was pumped into the rivers or waterways at night by the hundreds of gallons so as to get rid of it at the least cost, even though violating the local laws in doing so. It was a long time before it was thought worth while to burn it under the boilers. This is now being done in most plants and the coal consumption for steam purposes in the gas industry has been materially lessened thereby. In some localities there is a good market for this tar and it is hoped that if its use in boilers is discontinued, improved methods of burning the breakage from the gas (lump) coal will be used. This breakage amounts to about seven per cent. by weight of the total lump coal and the latter is usually quite high in cost, therefore, the most economical means of burning the breakage should be found and practiced.

Considerable warm water is needed about a gas works in the winter. The engines used for driving the gas blowers and other purposes might advantageously be run condensing and the warmed circulating water passed out in those systems requiring warm water. These systems would, in a measure, act as cooling towers. It should not be difficult to carry the desired vacuum on the engines or turbines and at the same time maintain the required temperature in the systems requiring warm water.

We know of one plant where this manner of heating is being successfully practiced in keeping a large gas holder supplied with warm water. Conditions here differ somewhat from those existing in a plant where nothing but gas is made. This station furnishes current for power and lighting, and, of course, the turbines are of greater power than the engines used for blowing gas; consequently they furnish more exhaust steam and are able to keep the water in a large gas holder above 32 deg. even in exceedingly cold weather. But, consider the number of gas works there are that are combined with electric-generating plants and under the same management. Practice shows that it requires about 150 boiler horsepower constantly to keep the water in a 5,000,000-cu.ft. gas holder at the required temperature after it has been heated. Think of the coal it is possible to save then by heating the numerous holders throughout the country by warm circulating water from condensers.

After all, the average gas-works engineer has received his mechanical-engineer degree or he has had a goodly amount of boiler practice and he can make the steam end of his plant economical if he will. All that is required is to bring to his mind the fact that there are other important things in engineering beside gas making.

⁂

A Good Example

A few months ago the gas company in Indianapolis voluntarily declared a further reduction in its rates. While this benefited only the large consumers, the point is that it was not necessary to force a reduction by legislation or the control of a public-service commission. There would be more such instances if more of our public utilities gave as much attention to striving to reduce their costs and thereby their charges as they do to lobbying. It is high time that the engineering and not the political talent in a corporation should come in for the chief share of recognition.

Commenting editorially on the gas-price reduction the *Indianapolis News* said: "Indianapolis is fortunate in possessing at least one public-service corporation that regards the business of supplying the public with its necessities as an affair of mutual benefit."

As a consequence this company has no anxiety over laws that may be passed, for laws are not created to affect the good but the criminal. Most public-service corporations remind us of the average boy who would rather spend his ingenuity in getting out of the punishment his disobedience earned than to be good in the first place. When will our utilities corporations grow up?

⁂

Did you ever try plotting curves showing the coal consumption compared to the evaporation and kilowatt output? Try it and keep the chart in the boiler room. The men will better results or "bust." That's the spirit it creates.

⁂

Don't be afraid to let the oiler key-up and put in a unit on the board, set pump valves and such like. Let him take the various meter readings occasionally, too. Polishing brass and filling lubricators does not make real oilers.

READERS WITH SOMETHING TO SAY

Compound Traction-Engine Diagrams

The inclosed cards were taken from a 6 and 9 by 10-in. compound traction engine equipped with a Giddings valve and having a single eccentric. The engine is reversible by suitable gear, which slides the eccentric over the shaft in the usual way. The boiler pressure was 80 lb. and a 40-lb. spring was used; the engine ran at 200 r.p.m. The engine was operating satisfactorily apparently, but when the indicator was applied, diagrams, Figs. 1

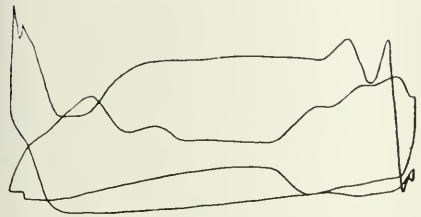


FIG. 1

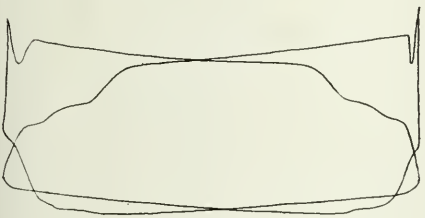


FIG. 2

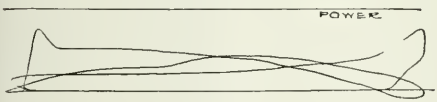


FIG. 3

FIG. 4

Diagrams from Compound Traction Engine

and 3, were obtained. After adjusting the valve rod to the proper length the result was as shown in Figs. 2 and 4. No further change was made, although I believe an increase in the lead would be beneficial.

I should like to hear comments on these diagrams from anyone interested.

Memphis, Tenn. F. P. Read.

Water-Service Connections Changed

We supply an adjoining office building with light, heat and hot water; the water being used in the lavatories. The original system of furnishing the hot water is shown

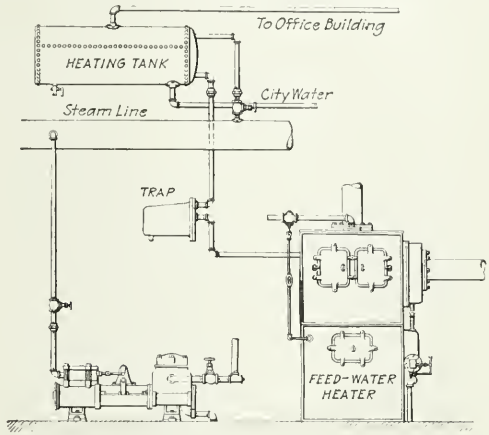


FIG. 1

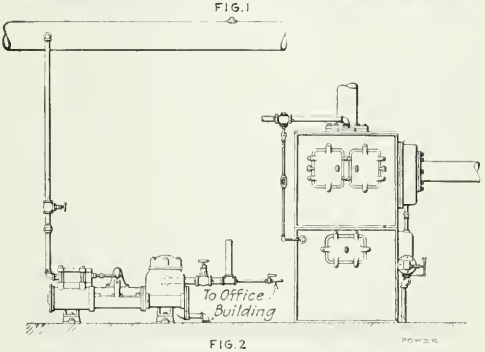


FIG. 2

Hot-Water Service-Pipe Connections

in Fig. 1. Securing the consent of the manager we made the changes shown in Fig. 2.

When one considers that the office force works only nine hours per day (the plant operates 24), the old way of heating the water was rather expensive. With the present layout we have done away with 300 ft. of ¾-in. pipe, a trap and the heating tank. The pump shown is a boiler-feed pump, so there is boiler pressure on the service-water lines, but in the two years this system has been in operation we have experienced no trouble of any kind.

Roscoe Willey.

Lamoni, Iowa.

[Connections, such as shown in Fig. 2, are hardly to be recommended, especially if the boiler pressure is over

80 lb. Pump governors will sometimes fail to act when the feed valves are closed and with connections like the above the service-water lines would be subjected to too high a pressure.—Editor.]

Cleaning Plugged Feed Pipes

We have two return-tubular boilers, and the feed water contains a high percentage of scale-forming properties; the feed lines plug up in three months and I have to renew all piping from the pump to the extreme end of the delivery pipe. The fittings in the connections stick so that they can hardly be turned with a 3-ft. chain tong.

The dread of the job helped me to plan out the following. I had a drill bit made of a piece of ¼-in. strap iron, similar to an ordinary coal-drill bit. Then a ½-in. pipe fitting was welded to the end, so I could screw on any length of pipe. Then all the ells on the feed lines were displaced by crosses and tees.

Now, when I wish to loosen the scale in the pipe, I take the plugs off the crosses and tees and insert the drill. The drill is about ⅛ in. smaller in diameter than the inside diameter of the pipe.

Roy L. Peterson.

Knoxville, La.

Peculiar Experience with Air Pump

Our air pump, connected to a large jet condenser, had been pounding and acting queer for some time. The first indications were light knocks and pounds. Apparently the knocks were in the connecting-rod or cylinder, but keying up on the crank and crosshead brasses helped but little and the remedy lasted only for a short time.

At times the pounding was unusually severe for a day at a time and longer, and then it would suddenly quiet down again. The valves of the air pump were gone over thoroughly, the steam valve examined and the clearance of the steam and air cylinders checked, and all found correct. All brasses were taken up and all lost motion eliminated, but the noise remained.

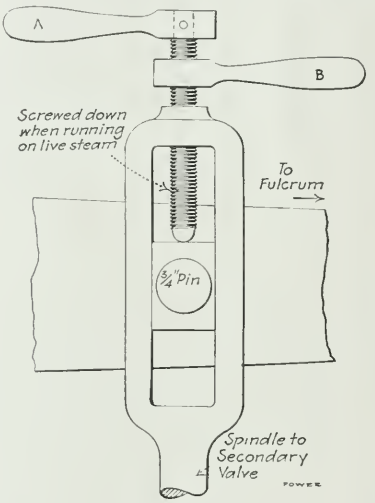
One day the pump started an abnormal racket and was shut down at once. Investigation showed that the piston rod broke close to the piston. A new rod was ordered and put in, the pump examined and started again. The noise was as bad as ever.

Then a series of serious accidents to the pump followed. The bedplate cracked, another piston rod broke and the crosshead split through at the pin bore. Just before the time for the day shift to come on duty the pump began a terrific pounding and was shut down. The night crew claimed it was due to water in one of the cylinders and left it to the day shift to "fight it out." Drains were unusually well provided for and apparently in good working order. Later the check valves in the cylinder drain pipes were found to be all worn out so a pair of new ones were put in. The pump ran smoothly now, but its doing so did not clear the mystery of where the water came from. The drain pipes from the air cylinder were found to end in a trench for the pump-suction pipes in the basement, and some conscientious steam fitter in connecting up the pipe had run it nearly to the bottom of the trench which at times was partly full of water. When the check valves failed, this water was drawn into the pump and caused all the trouble.

Thomas G. Thurston.

Improvement to Secondary Valve of Turbine

When running our low-pressure turbine we have to change over from exhaust steam to live steam about six times in every 24 hours. This is done by screwing down the ⅜-in. set pin or screw shown, thereby lifting the valve to admit live steam, after which we close the exhaust-steam valve. The arrangement sent out by the builders had a small square left on the top of the setscrew and a ⅜-in. jam nut was provided to set the screw when screwed down. This necessitated the use of two wrenches,



Adjusting Screw of Secondary Valve of Turbine

which were not usually in place when needed, as sometimes it is necessary to quickly change over from exhaust to live steam to avoid a shutdown.

In place of the former arrangement I turned up two small handles *A* and *B* and filed out a square hole in *A* to fit the screw and secured it by means of a pin. In place of the nut I tapped out the other handle and now we can operate the valve without losing time looking for wrenches.

J. A. Campbell.

Providence, R. I.

Air-Driven Pump Freezes

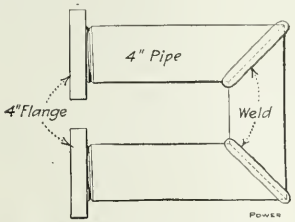
Can anyone tell me how to keep a small Snow pump from freezing under 50 lb. gage pressure without the aid of fire or other heating appliances. The pump stands about 300 yd. from the air compressor, which furnishes air to run the pump, no steam being used.

H. R. Leonard.

Uniontown, Penn.

Economizer Repair

We have an economizer containing 600 tubes, made up sections with goose necks to take up the contraction id expansion. One of these necks failed, and as the onomizer could not be spared for any length of time a



Home-Made Return Bend

oose neck was made out of three pieces of 4-in. pipe and o flanges, as shown in the sketch. The two welds were ade with acetylene gas and were built up strong. This pair stood the test and was used until a new goose neck uld be secured.

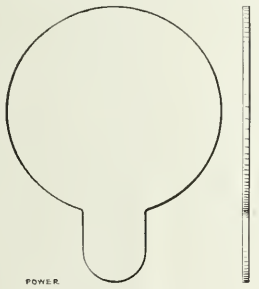
Frank W. Bellinger.

St. Paul, Minn.

Renewing Gaskets in Flanges

When placing a ring gasket in a joint in a vertical pipe e gasket sometimes falls down in the pipe. When such ints will not come apart much, we overcome gasket-sertion troubles as follows:

After removing, say, one-half the bolts, drive in be-reen the joint a steel wedge, until the joint opens about



Sheet-Iron Gasket Holder

in. Scrape the old gasket out and see that the flanges e clean. Cut the new gasket to the required size, inside ge of the bolt holes and lay it on a piece of sheet iron the same diameter or a little less. Cut the sheet iron the shape shown, lay the gasket on the plate and slide th in. When they are touching the back bolts, hold the sket with a rule or pocket knife while the plate is with-awn. It is well to have a number of different-sized ates on hand.

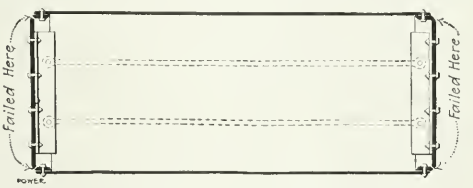
J. Jeffries.

Chicago, Ill.

[A plate of this kind may assist in putting a gasket in large-diameter flange, because a thin and flexible gasket ll sometimes strike the internal diameter of the flange the back end; it should hardly be needed with small nges, say, 6 in. or less.—Editor.]

Why Did Hot-Water Tank Fail?

The illustration shows the construction of a hot-water tank which gave out after only five years of service. Was failure due to the breathing action we hear so much about in connection with lap-joint boiler construction? This tank was subject to a pressure of from 90 to 100 lb. per



Construction of Tank That Failed

sq.in. with practically no air cushion to counteract the ramming effect of the pump plunger.

As seen from the sketch the heads were stiffened by angle iron, but with no through rods to hold the latter in position it makes a poor substitute for bumped or braced heads.

The heads were cracked and pitted completely through, nearly all around the circumference at the point shown by the arrows and were about ready to blow out when discarded for a new tank.

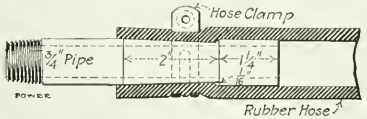
I would like to hear readers' opinion as to the cause of the failure.

R. Cederblom.

Chicago, Ill.

Steam-Hose Clamp

After having considerable trouble with a steam hose blowing off of the connection, I made the clamp shown. A piece of common ¾-in. pipe is turned to a taper and



Clamp Connection for Steam Hose

having a shoulder $\frac{1}{16}$ in. deep and 1¼ in. from one end of the hose. The hose should be put on this pipe and clamped.

We have a hose with a connection like this which has been in use for the past four months and it withstands a pressure of 115 lb. of steam and has never shown any signs of leaking or tendency to blow off.

H. R. Williams.

Grand View, Tex.

Mark for Lubricator Feed-Valve Wheel

It is convenient to have a mark on the feed-adjusting valve wheel of a lubricator. Instead of cutting a notch in the wheel as is common, a hole drilled in the wheel and a brass brad driven in is much better.

Harry D. Everett.

Fort Snelling, Minn.

QUESTIONS BEFORE THE HOUSE

Experiments on Efficient Boiler Operation

In the June 3 issue, there appeared an article entitled "Experiments on Efficient Boiler Operation," by B. W. Rogowski and, as I am interested in the subject of the combustion of all kinds of fuel, I have gone over the article very carefully and so far as I can see, the writer has failed to do more than to show that he apparently improved his efficiency by cleaning his boilers. He does not discuss the vital points, nor show what economy he actually obtained.

He states that the boiler fuel depends largely upon "the choice of coal adaptable to the plant conditions, and which would generate the greatest amount of heat at the lowest cost of handling and consumption." He does not state the location of the plant in question, the price of the various sizes of anthracite, such as pea, buckwheat, rice and barley; nor the make of boilers and type of batfling in question. It is impossible, therefore, to discuss with any amount of intelligence the correctness of the writer's statements, but it appears that the matter has not been approached from the proper viewpoint.

If other coals were available, such as mentioned, that is, the small sizes of anthracite, it certainly would pay to change the grates to accommodate the fuel and not have the fuel accommodate the grates. With the excellent stack draft very fine showings should be made with the smaller sizes of anthracite fuel, in conjunction with mechanical draft-blower apparatus.

Flue-gas analysis, when it comes right down to boiler-plant efficiency, means very little, except the CO_2 reading, which, I believe, it is well to obtain, and if possible to record with a gasometer; but it is not flue-gas analysis that is required but rather how low the cost to evaporate 1000 lb. of water from and at 212 deg. F. may be made. If the efficiency of the plant is to be known, all tests are of no avail unless this figure is obtained, using various fuels, which the writer evidently has not done, or if he has, has said nothing about it. If the writer is determining efficiency of his plant purely by the analysis of the flue gases he is apt to be very much in error, since his boilers may be in a very dirty condition inside, which will have no effect on the flue-gas analysis and yet will greatly affect the evaporation.

Experiments with the thickness of the fuel bed were made and it seems, according to his results, that a 4½-in. bed was found most efficient with mechanical draft and a very high stack with good draft and grates of 25 per cent. air space. I do not agree with him in view of the fact that his rate of combustion is exceptionally low; 17 lb. per sq.ft. of grate surface. Cleaning for a 4½-in. fire means a very great loss and is unnecessary, as with both mechanical and natural draft a 10-in. fire can be easily handled and maximum efficiency still maintained.

The writer states further on, that the combination of this highly preheated air and carbon monoxide at the bridge-wall secured complete combustion. Evidently this boiler has horizontal baffles, and I should be glad to learn as to the correctness of this assumption.

It is stated that alternate firing gives best results, that is, one-half of the grate at a time, and the general conclusion is stated as a fact and applied to anthracite generally, which is erroneous. If this were done with No. 3 buckwheat or barley more air would pass through the well burned half of the grate, rather than through the green coal, and even with No. 1 buckwheat and natural draft, this will hold true. It is also stated that the fire must not be disturbed except when cleaning. It is impossible to burn rice or barley and even No. 1 buckwheat, without leveling the fire occasionally with a leveling rod.

Of all anthracite coals, such as pea, buckwheat, rice and barley, buckwheat is most expensive, as it contains less heat units per dollar. Of course, it must be compared with the other sizes from the same vein. I might state here that with No. 3 buckwheat, or barley, of quality such as was named (12,500 B.t.u.) a fire can be obtained which is incandescent and which will evaporate more steam per pound of coal than No. 1 buckwheat of the same vein.

It would have been a good thing had Mr. Rogowski given more information regarding his tests, stating how they were made, analysis of the coal, how the water was weighed, the conditions of the boilers, percentage of boiler rating developed and pounds of water evaporated per pound of coal.

V. H. Carples.

New York City.

⁂

Measuring Water during Boiler Tests

In looking over Mr. McHollan's feed-water piping, as illustrated in the letter on the above subject in the June 10 issue, for measuring water in boiler tests, I notice that he proposes to draw or lift hot water from two flat storage tanks, located below the water chambers of the boiler-feed pumps.

Assuming that the feed water is as it should be, very near the boiling point, I cannot see how the arrangement could work successfully if installed, as shown by Mr. McHollan, for the reason that it is impossible to lift hot water any considerable distance by suction, as the vapor pressure or tendency to turn it into steam closely approximates and counterbalances the atmospheric pressure. If it is attempted to lift hot water by suction the body of the water will not rise, but instead, steam or vapor arises from the surface and flows to the pump. This vapor and steam in the water chambers will, of course, cause the pump to race and knock without delivering any appreciable amount of water.

The cure for this condition is to have the water flow to the pumps by gravity with sufficient head to lift the suction valves in the pump, to overcome the friction in the piping and to flow with sufficient velocity to follow

the pump plunger in a solid body. Therefore, in Mr. McHollan's layout, the pumps should be lowered sufficiently to allow the hot water to flow from the collecting tanks by gravity.

The points above mentioned bring to mind one of my experiences with an open-heater installation, as shown in Fig. 1. The boiler-feed pump was about 30 ft. from the heater and the situation was such that it was impossible to get more than 2-ft. drop between the hot-water

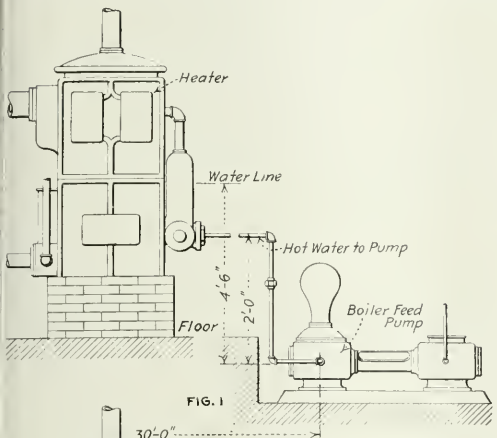


FIG. 1

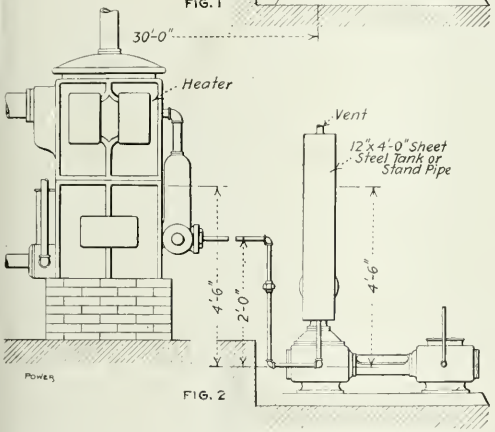


FIG. 2

HEATER CONNECTIONS TO PREVENT POUNDING OF PUMP

outlet of the heater and the water chambers of the pump. While we could pump the water we were annoyed quite often by the racing and knocking of the pump when the slugs of vapor collected. Realizing that it was necessary to keep a constant supply of water to follow the pump piston, I installed a standpipe arrangement above the feed pump, as shown in Fig. 2. This tank maintained a head of water at the pump equal to the height of the water line in the heater. After putting this arrangement into operation, the trouble from pumping the hot water was eliminated.

WILLIAM TAYLOR.

Philadelphia, Penn.

[Troubles of this kind are common and the standpipe should eliminate them.—EDITOR.]

Japanese Electrical Manufacturers

Regarding the Japanese as electrical manufacturers, commented on in POWER for May 13, 1913, an agent of one of our leading electrical manufacturers recently told me his firm had been requested to bid on an order from Japan for one or two only of about every kind of electrical apparatus they manufactured. He could only conclude, from the peculiar makeup of the order, that the instruments were to serve as models to be imitated.

DONALD M. LIDDELL.

Elizabeth, N. J.

Large High-Vacuum Condenser Test

I have noted with interest Mr. De Laval's communication in your issue of May 27, in which he refers to the test of the Illinois Steel Co. condenser, published in the Feb. 25 issue.

Mr. De Laval assumes that the vacuum readings were taken on the air-pump suction, and he is apparently under the impression that in any condenser of this size there must be a loss of approximately 1 in. in vacuum between the turbine buckets and the dry-air pump-suction opening.

The test in question, which was conducted by the engineering department of the Illinois Steel Co., was one of the most complete condenser tests that has been made. These engineers were only interested in the vacuum at the turbine, and, hence, the vacuum readings, instead of being taken at the air-pump suction, as Mr. De Laval assumes, were actually taken at four points at the top of the shell in the space directly beneath the turbine buckets.

It may also interest Mr. De Laval to know that the total loss in this condenser averaged less than 0.2 of an inch.

There is a further reference made to the test of the dry-vacuum pump, where Mr. De Laval makes certain deductions as to efficiency, by taking readings from indicator cards and making no allowance for barometer corrections. The dry-vacuum pump test was made at the same time as the condenser test, and is based on operating conditions where the corrected vacuum varied from 28.3 to 28.9 in.

Mr. De Laval asked if the Wheeler Condenser & Engineering Co. is willing to guarantee the efficiencies obtained by the Illinois Steel Co.'s engineers, and I beg to state that we would not only be pleased to duplicate this performance, but to improve on the results in many respects.

J. J. BROWN.

Carteret, N. J.

Name for Steam Stuff

The various names for steam suggested by C. S. Palmer in the May 20 issue are noted. If we are really hunting for a new name for our faithful friend, why not "superheated steam" for superheated steam; "steam" for dry steam; "wet steam" for wet steam. Otherwise, if a spade is not a spade, what is it?

E. R. PEARCE.

Rochdale, England.

INQUIRIES OF GENERAL INTEREST

Engine Speeds—About what are the respective speeds of Corliss and high-speed engines in common use?

A. C. M.

Corliss engines are made to run at 80 to 150 r.p.m. High-speed engines are made to run at speeds of 150 to 700 or more r.p.m.

Boiler Evaporation—What is the normal average of evaporation of water in a steam boiler, in pounds of water per pound of coal?

H. R. B.

In average good boiler practice 8 lb. of water is evaporated from and at 212 deg. F. (or equivalent) per pound of coal.

Electric Lamp Load—What would be the load on a dynamo lighting 50 incandescent lamps, all in one building but on four floors and connected by about 500 ft. of wiring? Our dynamo is rated at 5 kw., 125 volts, 40 amperes; is it large enough?

W. Y. J.

Fifty 16-cp. carbon-filament electric lights would require about 25 amperes with current at 110 volts, or 2.75 kw., and the dynamo which you describe should be ample for supplying the lamps. Tungsten lamps for a given candlepower consume much less current and nearly twice as many can be lighted with the same current consumption.

Varying Receiver Pressure—What can cause the receiver pressure in a cross-compound, nonreleasing, shaft-governed engine to rise and fall? The governor is understood to control the cutoff of both the high- and low-pressure cylinders. There is no change in the load or in the initial or back pressure?

M. B. H.

Diagrams taken from the engine would undoubtedly show that there is a hunting action of the governor, producing a constantly varying per cent. of cutoff. It is doubtful if the load can be said to be absolutely constant because there are always slight changes due to friction variations, etc.

"No-Voltage Release"—What is meant by a "no-voltage release," of what does it consist and what is its purpose?

F. E. A.

The correct term is "low-voltage release," although the other is frequently used. It is a relay wound so as to trip the circuit-breaker, or switch, when the voltage falls below a certain predetermined value, usually 50 per cent. of the normal voltage. These devices are used in connection with motors to insure proper starting. If the voltage should drop suddenly, while the motor is running, to such a low value that the motor stops, and then should come on again the motor would not be damaged by a rush of current, because the low-voltage release would have opened the circuit.

Detecting Leaky Slide Valve—How can a leaky slide valve and a leaky piston be detected?

J. C. M.

A leaky slide valve can be detected from the character of the exhaust. If the valve leaks, steam will be discharged after the valve has cut off, i.e., there will be a continuous stream instead of an intermittent discharge. Another way is to place the engine so the valve will be in the middle of its travel, then block the engine from turning. If the valve is tight no steam will escape from the exhaust pipe or cylinder pet-cocks when steam is admitted by the throttle valve. A leaky piston is best detected by removing the cylinder head and, after blocking the wheel or crosshead, with the piston at about one-half stroke, open the throttle valve and observe whether steam blows past the piston.

Finding Pump Size—What size pump, and what horsepower are needed to feed two 71-hp. boilers through a 1-in. pipe, 11 ft. long containing six ells, and through a closed heater 6½ ft. long containing 10 ft. of 1-in. pipe with 18 return-bend connections, and then back through a return pipe (1-in.) also 112 ft. long and containing six ells and four valves? The water must be lifted 15 ft. and delivered against 100 lb. boiler pressure.

A. M.

To feed two 71-hp. boilers would require

$$2 \times 71 \times 30 = 4260 \text{ lb.}$$

of water per hour, or

$$\frac{4260}{8.33} = 511.2 \text{ gal. per hr.}$$

or

$$\frac{511.2}{60} = 8.5 \text{ gal. per min.}$$

Reckoning the friction of each 1-in. valve or fitting as equal to that of 20 ft. of 1-in. pipe, then the total equivalent length of pipe would be

112 + (6 × 20) =	232
120 + (18 × 20) =	480
112 + (6 × 20) + (4 × 20) =	312
	1024 ft.

Referring to Plate 1 of diagrams of loss of head in pipes given in the Nov. 10, 1908, issue of "Power," page 778, it may be seen that water flowing in 1-in. iron pipe at the rate of 8.5 gal. per min. sustains a loss in head of 9 ft. per 100-ft. length of pipe, hence for 1024 ft., the loss of head to overcome friction would be

$$\frac{1024}{100} \times 9 = 92.16 \text{ ft.}$$

head or

$$92.16 \times 0.433 = 39.9 \text{ lb.}$$

or practically 40 lb. per sq.in., which would be the loss of pressure due to friction.

For pumping the quantity of water required per minute a 3x2x3-in. duplex steam pump running at about 60 r.p.m. would answer, but a 4½x2¾x4-in. duplex pump running at about 40 r.p.m., or a 5x3¼x8-in. single steam pump running at about 38 r.p.m. would give better satisfaction.

The total pressure to be overcome would be

$$40 + 100 + (15 \times 0.433) = 146\tfrac{1}{2} \text{ lb.,}$$

and pumping 8½ gal. per min., the net water horsepower would be

$$\frac{8\tfrac{1}{2} \text{ gal.} \times 231 \text{ cu.in. per gal.} \times 146\tfrac{1}{2}}{12 \times 33{,}000} = 0.726 \text{ hp.}$$

and if a steam pump is used it would require about

$$0.726 \times \frac{150}{30} = 3.63 \text{ b.hp.}$$

of steam.

Using a 1¼-in. suction pipe up to the heater, the power required would be about 10 per cent. less than by the restricted use of 1-in. pipe as above.

Pumping Power—What horsepower should be necessary to operate a pump delivering 526 gal. per min. against a pressure of 210 lb.? The water is delivered to the pump so that no lift is necessary. With current at 1¾c. per kw.-hr., what would it cost per month of thirty 8-hr. days to drive the pump by a motor?

J. C. G.

Pumping 526 gal. per min. against a pressure of 210 lb. per sq.in. requires

$$\frac{231 \times 526 \times 210}{12 \times 33{,}000} = 64.43 \text{ net horsepower,}$$

and allowing 60 per cent. efficiency of the pump, this would require

$$\frac{64.43}{60} = 107.38 \text{ net or brake-horsepower}$$

to be applied to the pump. Allowing 85 per cent. efficiency of an engine and transmission machinery would require an engine to develop

$$\frac{107.38}{0.85} = 126.32 \text{ i.hp.}$$

With electric current charged for at 1¾c. per kw.-hr., allowing 91 per cent. efficiency of the electric motor and 60 per cent. efficiency of the pump, the charge for current, running eight hours per day and 30 days per month would be:

$$\frac{(231 \times 526 \times 210)}{12 \times 737.3 \times 60)} \times \frac{(\$0.0175 \times 8 \times 30)}{(0.91 \times 0.60)} = \$369.72$$

ENGINEERS' STUDY COURSE

Heat Lost in Flue Gases

Heat Lost up Chimney

When a pound of fuel is burned under a boiler its available heat is distributed in a number of ways. The largest part is transferred to the water within the boiler and converts some of it into steam. But, from 20 to 60 per cent. is lost in various ways. The greatest loss is due to the heat carried up the chimney by the flue gases, and,

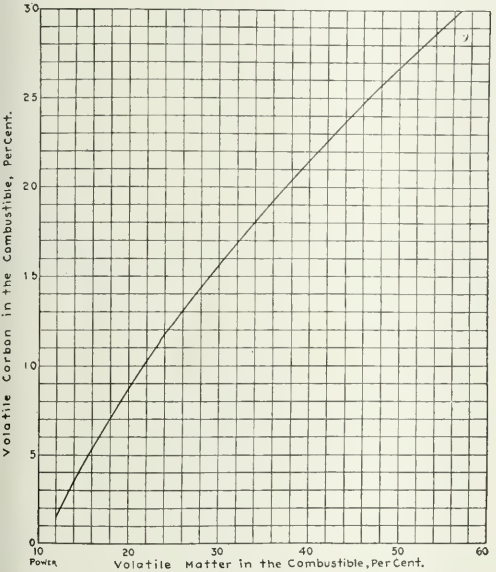


Fig. 1. Chart for Determining the Carbon in the Volatile Matter

as this loss depends to a large extent upon the skill and care employed in operation, it is one in which every engineer should be greatly interested and about which he should be thoroughly posted.

If after a pound of flue gas has come in contact with the heating surface of the boiler and has given up some of its heat to the water within, it passes out to the chimney at, say, 500 deg. F., how much heat is lost or carried up the chimney?

All the heat that the gas contains, over and above what the air and coal from which it was formed contained, was derived from the combustion of the coal. Then to all intents and purposes the heat lost with every pound of flue gas, expressed in B.t.u., must be the product of the number of degrees difference in temperature between the air entering the furnace and the flue gas going out of the boiler, multiplied by the heat required to raise the temperature of a pound of flue gas 1 deg.

Specific Heat

This brings us to a consideration of "specific heat," a term often employed in steam engineering. By definition, the amount of heat required to raise the temperature of a pound of water 1 deg. is one B.t.u. A pound of air requires about one-fourth as much heat as a pound of water for a rise of 1 deg., and a pound of iron requires only about one-eighth as much as water. The quantity of heat required to raise the temperature of a given amount of substance a given number of degrees depends upon the nature of the substance and is different in almost every case. Hence, in problems involving quantity of heat and quantity of materials, it is often important to know the amount of heat required to cause a rise of 1 deg. in temperature per pound of material under consideration. This quantity is called the specific heat of the substance. Thus, the specific heat of iron is said to be 0.13, because a pound of iron requires 0.13 B.t.u. to raise its temperature 1 deg.

The specific heat of flue gas is not exactly known, nor is it uniform for all temperatures. That is, at low temperatures it is somewhat less that at high. However, the most commonly accepted value is 0.24, and, hence this is the one we will use.

Estimating Heat Lost in Flue Gases

The heat lost or carried up the chimney by the flue gases per pound of fuel burned can be estimated by multiplying the weight of the gases generated per pound of fuel by the specific heat of the gases and the difference in temperature between the gases leaving the boiler and the air entering the furnace. The answer expresses the loss in B.t.u. This calculation can be written as a formula, thus:

$$L = 0.24\ W\ (T - t),$$

where

L = B.t.u. lost up chimney per pound of fuel burned;

0.24 = Specific heat of the flue gases (or the amount of heat required to raise 1 lb. of the gases 1 deg.);

W = Weight of flue gases formed per pound of fuel;

T = Temperature of gases leaving boiler, degrees F.;

t = Temperature of air entering furnace, degrees F.

Weight of Gases per Pound of Fuel

To make the foregoing calculation it is necessary to know the weight of flue gases formed per pound of fuel burned. This is found by the following formula, which looks worse than it really is:

$$W = 3.032\ C\left(\frac{N}{CO_2 + CO}\right) + (1 - A)$$

where

W = Weight of flue gases formed per pound of fuel burned;

3.032 = A constant;

C = Decimal part by weight of carbon (total

carbon) in the fuel as fired;

N = Percentage by volume of nitrogen in the flue gases;

CO_2 = Percentage by volume of carbon dioxide in the flue gases;

CO = Percentage by volume of carbon monoxide in the flue gases;

A = Decimal part by weight of ash in the fuel as fired.

The proximate coal analysis does not show the decimal part, proportion or percentage, of total carbon in the fuel; it only shows the percentage of fixed carbon. Consequently, in order to use the foregoing formula, we will have to estimate or guess at the amount of carbon contained in the volatile matter, add this to the amount of fixed carbon and consider the sum as being the amount of total carbon in the fuel. The accompanying chart, Fig. 1, developed by Professor Marks and originally published in POWER for Jan. 14, will give results close enough for our purpose.

Estimating Total Carbon in Coal

To calculate the carbon in the volatile, add together the percentage of fixed carbon and volatile matter as shown by the proximate analysis and divide this sum into the percentage of volatile matter. The quotient multiplied by 100 gives the percentage of volatile matter in the combustible. Having found this, locate a corresponding point on the scale at the bottom of the chart and trace an imaginary line straight up to the curve and then horizontally to the scale at the left margin which gives the percentage of volatile carbon in the combustible matter. Multiply the percentage thus found by the percentage of combustible in the coal and divide by 100 to obtain the percentage of volatile carbon in the coal. Add this percentage to the percentage of fixed carbon in the coal as shown by the proximate analysis to obtain the total carbon in the coal.

To illustrate with a numerical example, assume that we wish to estimate the percentage of total carbon in a coal with this analysis: Moisture, 6.2 per cent.; volatile matter, 16.8 per cent.; fixed carbon, 70.7 per cent.; ash, 6.3 per cent. The sum of the percentage of fixed carbon and volatile matter is

$$70.7 + 16.8 = 87.5,$$

and this, divided into the percentage of volatile matter and multiplied by 100, gives

$$\frac{16.8}{87.5} \times 100 = 19.2 \textit{ per cent.}$$

volatile matter in the combustible.

Locating the 19.2 point on the scale at the foot of the chart and tracing an imaginary line straight up to the curve and over to the margin we get 8.2 as the percentage of volatile carbon in the combustible. And this multiplied by 87.5, the percentage of combustible matter in the coal, and divided by 100, gives

$$8.2 \times 87.5 \div 100 = 7.2,$$

the percentage of volatile carbon in the coal, which, added to the percentage of fixed carbon in the coal, gives

$$70.7 + 7.2 = 77.9,$$

the percentage of total carbon in the coal.

The next lesson will tell how the nitrogen in the flue gases is estimated and how to measure flue-gas temperature. There will also be some practice problems.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Office-building managers are showing much more interest in power-plant efficiency than formerly. It isn't surprising that this is so; the surprise was that they were so long discovering their sore need for better equipment, better engineers, better returns.

⁂

Even the most skeptical must admit that the public service commissions are doing good work when they compel admission from public-utility heads that the commissions are commendable. Usually, a corporation cries persecution unless it can conduct its business just as it sees fit.

⁂

Man says he has a safety razor operated by electricity, and it works beautifully. Now he wants a new motor, as the present one, about the size of an apple (perhaps a pippin), is too bunglesome. One about the size of a B. & S. No. 00 hen's egg, he calculates. The razor saws, no scraping whatever. Great! Now for that device with which you can cut your own hair—if you have any; some folks haven't.

⁂

'Bout time old Foodforthought was pensioned; he's sure being worked overtime in the papers. Some of these writer chaps must be eating around in "food-for-thought" places and suffer from literary gout or a superfluity of adipose tissue.

⁂

It's said that New York City intends utilizing the exhaust steam from one of its power plants to help make twenty-five tons of ice daily and sell it at cost price. More municipal misuse of the down-trodden central station. And the more ice the city makes, the hotter will be the central-station people.

⁂

"Don't be content with doing only your duty; do more than your duty."—Andrew Carnegie.

We like this as an aphorism; it has a wide latitude and a broad meaning. But the big hitch in the "doing" business is that its marts are crowded something fierce with ginks who are either doing nothing, or everybody, or just doing. The business is too highly specialized, there's too many competitors, too many enthusiasts—and too many professional reformers.

⁂

One of the most successful kale-gatherers we ever assisted in getting rich had this slogan. "Don't hold a man down; hold him up!" And he practiced as well as preached this doctrine from the rising of the sun to its going down thereof. Hold 'em up? It was Use no Hooks! and This Side Up with Care! but how he could hold, and keep hold.

⁂

He had more than a "howdy-do" acquaintance with Andy, and this is probably where he got the idee of "doing" more than his duty—many more. Mr. Carnegie's one desire is to die poor, and he has duty enough without trying to overdo himself at the rate he is going. If he lives 'till he's poor, the doing business will by that time have slumped considerably, and his impetuous remarks anent the more than duty stunt will have doubtless been forgotten.

⁂

When Wall Street "cuts a melon," it divides up a big hunk of money made on a smart deal; when the N. Y., N. H. & H. cut its Mellen the other day it took a big hunk of subsidiary property from out of his control. My word, old chap, a rawther Mellencholy proceeding, eh what?

⁂

The New Haven system has been further disordered by the Interstate Commerce Commissioner's scathing arraignment of its mismanagement. The commission recommends that the road divest itself of its trolleys. This is a dignified way of saying: "You're off your trolley."

⁂

Proper appreciation is lacking, says "Engineering News," for the hard-working air-brake inspector, to whom is due the safety of the traveling public. Here's credit for one faithful soul in obscurity. Somebody please say a kind word for the power-plant engineer?

The Care and Repair of Rubber Belts

By Robert Moore

SYNOPSIS—A well illustrated article giving instructions for splicing and stitching rubber and canvas belts. The author does not recommend the use of rubber belts on small pulleys. Dressing for rubber belts is also considered.

From time to time one sees articles on the splicing and general repair of leather belting, but rubber and canvas belts seem to have been neglected.

Nevertheless, they need as much attention as their cousins of leather, particularly in the splicing. Some time ago the writer installed a 36-in. belt that was 50 ft. between centers. As belts of this sort are prone to stretch when new, care should be taken in stretching the belt over the pulleys.

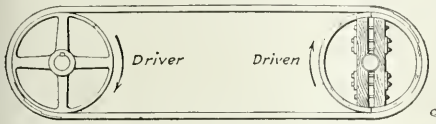


FIG. 1

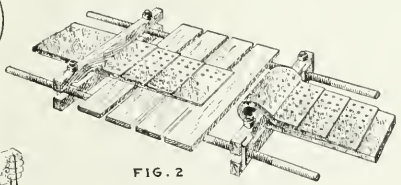


FIG. 2

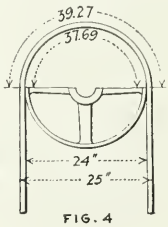


FIG. 4

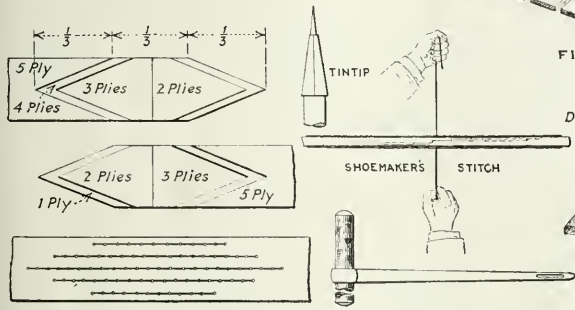


FIG. 3

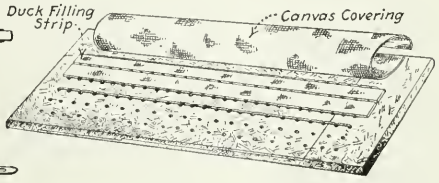


FIG. 5

Stitchings, Splices and Tools Used In Repairing Rubber Belts

First allow 1/8 in. to each lineal foot of belt for stretch, place the belt in position, put on the clamps and draw them tight. Do not be afraid of breaking the belt as five-ply 10-in. belt will stand a strain of 10,000 lb., larger ones in proportion; the pulley will collapse first. Take all the tension the bearings will stand, then turn the shaft slowly back and forth until the clamps touch the pulleys; taking up the slack as it is recovered from the upper half. Neglect to do this will stretch only one-half of the belt, and is apt to cause it to run out of line.

After thoroughly stretching the belt, proceed with the lap, which for a belt of this kind should be 45 in. long. Bear in mind that the lap should always point in the direction of travel over the pulley as in Fig. 1. By so doing any slip of the pulley will have a tendency to smooth down the lap.

Place the board on the clamp rods to rest the splice on; then draw a line squarely across the belt 47 in. from the end. Lay the section off in 2-in. squares, starting one inch from the outer edge as in Fig. 2. Now punch 1/4-in. holes where the lines cross. As there are six piles there will be three cuts or scarfs, as shown in Fig. 2. Cut a line just the depth of two plies at the 45-in. line and peel off these two thicknesses; do the same at the 15- and 30-in. lines.

Scarf the other end, place the halves together and punch holes in the lower half, inserting the punch in the holes in the upper half. By so doing, the holes will be directly opposite each other. Cleanse the surfaces with naphtha and apply a liberal coating of the best rubber cement. Allow this to dry until it will not stick to the fingers, then place the laps together, starting at the edge and rolling the upper one out as it is being cemented so that air may not be entrapped between the surfaces. Then sew the outer edges, using the shoemaker's stitch, shown in Fig. 3. Alternately roll and pound the joint until it is perfectly flat, then sew each row of holes as was done with the outer ones.

Cut filling strips the width of the space between lacings (most belt companies sell this duck all prepared), and give them several coats of rubber cement on each side. Clean the face of the belt between the laces with naphtha and give it a liberal coating of cement. When each surface is dry, that is, when the finger placed lightly to the surface will not adhere, place the strips between the lacing and roll them down. Now take a piece of duck, the width of the splice, but 4 in. longer, and cement this to the face of the belt, covering the joint. By so doing the lacings are protected and except for the occasional renewal of the outer covering the joint is as durable as the belt itself.

In sewing belts of this kind, tip the laces like a shoe string by bending a V-shaped piece of tin around the ends; another way is to use an eyed awl to pull the lace through the belt.

Belts smaller than 10 in. are butted and have a butt strap on the outer surface, this is known as the "back splice." Belts on grindstones, saws, rattlers, etc., where shippers are used will wear on the corners where they are butted, and the outer lace hole will soon tear away, if this form of joint is not used. Shippers for belts of this kind should always be of the roller type. In joining canvas belts always stagger the holes and do not have them less than $1\frac{1}{4}$ in. apart as the fabric is apt to crack across in cold weather.

Another form of joint, known as the "diamond splice," is used on generators with small pulleys as there is less shock when the lap passes over the pulley, eliminating all flicker of the lamps.

The diamond splice is made in much the same manner as the lap splice except that the scarfs are divided into three equal parts and cut as shown in Fig. 3, it is not so strong a joint as the lap splice, but it is more flexible, therefore, better adapted to small pulleys.

Many engineers condemn rubber belts as too cheap or they consider them as a poor substitute for those of leather. This is a mistaken idea. I personally know of rubber belts that have been in continuous operation for years under most exacting conditions, such as dust-laden grinding rooms, dye house where the belts were drenched with moisture and outdoor drives subject to all weather conditions.

I would not advise using rubber belts on small pulleys as the outer side of the belt must stretch and the side next the pulley compress. This creates a forward and backward motion between the plies of the belt and is apt to separate these plies.

On a given arc the stretch and compression are the same for one thickness of belt, so that increasing the diameter of the pulley lengthens the life of a belt as the stretch and compression are less per foot. As the thickness of the belt increases so should the diameter of the pulley. For instance, the arc of a belt ¼ in. thick, on a 2-ft. pulley would measure 37.69 in. next to the face of the pulley, while the outer edge would measure 38.48 in., a total distortion of 0.79 in. If the belt were ½ in. thick the outer edge would measure 39.27 in., giving a total distortion of 1.58, just twice as much; see Fig. 4.

So when more power is wanted and it is not advisable to increase the size of the pulley better results are obtained by widening the belt and pulley face than to increase the thickness of the belt.

To increase the diameter of the pulley to 48 in. would give a total distortion of 1.58 in. when using a ½-in. belt, but as the arc would measure 75.4 in., the distortion for each lineal foot would be halved.

Animal fats and grease should never be used on rubber belts. Boiled linseed oil is good; also equal parts of black lead, red lead, French yellow, litharge and enough Japan dryer to make it dry quickly. This will give a smooth polished surface.

Available CO_2 Percentages

By H. O'Neill

SYNOPSIS—Influence of hydrogen and air supply to fuel upon the possible percentages of CO_2 resulting from the combustion of fuel composed of carbon and hydrogen.

The author of "Available CO_2 Percentages," in the issue of Apr. 15, correctly states that the percentage of CO_2 in a flue gas does not in itself determine furnace efficiency, for the loss to stack of even a small amount of CO means, relatively, a large loss in available heat. Nor does highest CO_2 percentage necessarily mean highest efficiency.

However, his method of measuring the possible CO_2 percentage by the percentage of fixed carbon in the fuel is fallacious. If it were correct, CO_2 could not possibly be produced from the combustion of a hydrocarbon such as oil, which has no fixed carbon. It is certain that the combustion of such fuel does produce CO_2.

CO_2 percentage is determined by the air supplied per pound of combustible, and by the chemical composition of the fuel. Combustion of pure carbon in air produces by volume: Nitrogen, 79.1 per cent.; $CO_2 + O + CO$, 20.9 per cent. Here, the available CO_2 is 20.9 per cent., and the percentage of CO_2 obtained, depends upon the amount of air supplied in excess to that required for complete combustion, that is, CO_2 will approach 20.9 per cent. as a maximum by proper furnace design and operation.

What really determines the available CO_2 percentages is the available total of $CO_2 + O + CO$, or if the combustion is complete, the available total of $CO_2 + O$. This can be calculated only after an ultimate analysis of the fuel, showing the percentage of nitrogen, oxygen, sulphur, hydrogen and carbon.

Nitrogen fixed in the coal will appear in the analyzer

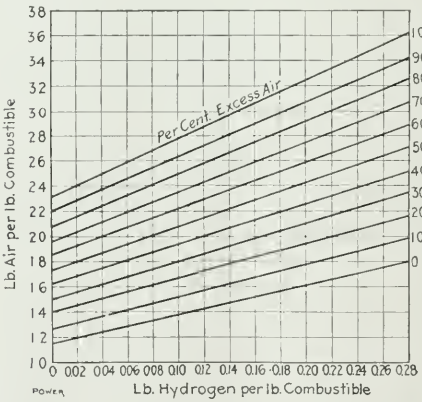


Fig. 1. Relation between Air Required for Complete Combustion and Proportion of Hydrogen in Combustible

in addition to the nitrogen of the air supplied to the fuel. Therefore, the percentage of the available total will tend to be under 20.9 per cent. Oxygen so fixed may combine directly with the fuel without being accompanied

with nitrogen, as in the case of the oxygen in the air supplied. Therefore, when the coal contains oxygen, the nitrogen residue will be decreased relatively, and the available total may run over 20.9 per cent., as is the case with the combustion of certain high-oxygen coals.

The combustion of sulphur in small percentages has an inconsiderable effect on the available total.

With practically all Eastern steaming coals, the hydrogen in combustion has the most important effect on the available total. It may be assumed within reason that

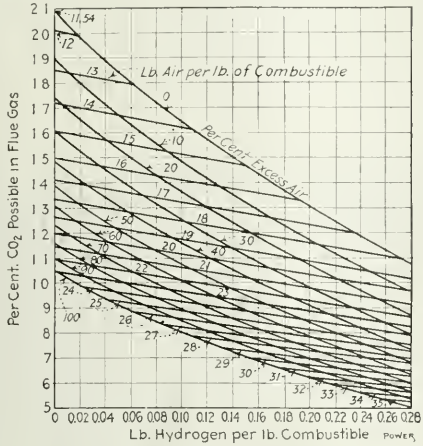


Fig. 2. Influence of Excess Air and Hydrogen in Combustible on CO_2 Percentage

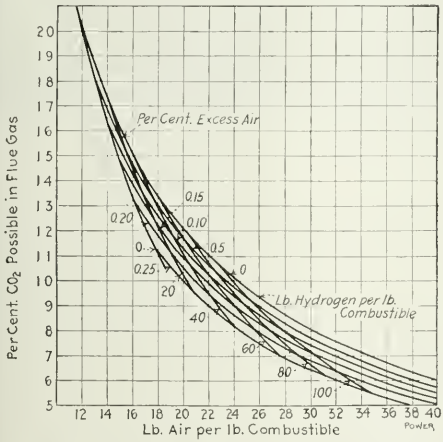


Fig. 3. Influence of Hydrogen, with a Given Air and Fuel Ratio, Upon CO_2 Percentage

combustible is composed of only carbon and hydrogen. This is true also of fuel gas and fuel oils except for a trace of sulphur.

The hydrogen in the coal combines with the oxygen of the air to form H_2O (superheated steam) which condenses in the Orsat, thus robbing the available total of a certain percentage of oxygen, so that it will be less than 20.9 per cent.

Fig. 1 shows the relation between the amount of air required for complete combustion and the proportion of hydrogen in the combustible. Figs. 2 and 3 show graphically the effects of hydrogen and air supply upon the CO_2 percentage. In all three charts the combustible is assumed to be carbon and hydrogen only.

With good steaming coal, from 4 to 5.5 per cent. of the combustible is hydrogen. If there is little nitrogen and oxygen contained in the coal, the totals of CO_2 and O in the flue gas will be from 18.5 to 19 per cent; that is, the maximum CO_2 available will be 18.5 to 19 per cent.

With good furnace design and operation, the CO_2 should average from 12 to 14 per cent. with from 6.5 to 4.5 per cent. oxygen.

Oil fuels usually run about 85 per cent. carbon and 15 per cent. hydrogen. In this case, the available CO_2 is not over about 14.5 per cent.

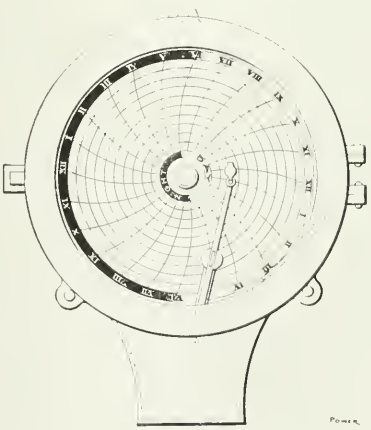
From the combustion of certain natural gases, where H is greater than 30 per cent., the available CO_2 percentage is even lower.

Therefore, analyses of flue gas for CO_2 under certain conditions may be misleading as indications or measures of furnace efficiency, unless the engineer knows his fuel. The charts shown are intended, principally, as an aid to visualizing the influence of hydrogen contained in fuel upon the results obtained in the ordinary flue-gas analysis.

New Recorder Pen Arm

Lifting the pen arm from the chart holder of a recording instrument, retaining it in a strained position with one hand, while the chart is changed with the other, requires considerable practice and dexterity to accomplish without spilling the ink or soiling the chart.

The Schaeffer & Budenberg Mfg. Co., Brooklyn, N. Y.,



Two Positions of the Recording Arm

has applied for patents on a new recording pen arm to be used exclusively on their "Columbia" recording gages, recording thermometers and tachometers, that does away with this objection. The arrangement consists of a pen arm proper, its pedestal, and an adjusting screw. The pedestal is directly connected to the recording element of the instrument, which is retained in place by its slight resiliency and with the aid of the pin on the adjusting screw.

When the chart is changed the recording arm is drawn away from the recorder by lifting it from the pin, and is allowed to drop to the right, the pedestal remaining stationary, as shown in the illustration. The obstructing pen arm thus being removed, the chart is easily changed and the recording pen replaced in its proper position.

Cookson Heater Improvement

The improved body of the Cookson heater is cast in one piece to give greater strength, durability and better appearance. The substitution of a single casting for the built-up plate body does away with bolts and calked joints, except for the oil separator, manhole and handhole covers and the pipe fittings; hence, there is no chance for leakage at the points which in the built-up heater are most apt to give trouble from this source.

This one-piece, cast-iron heater, which is built by the Bates Machine Co., Joliet, Ill., has large steam space, tray surface and filtering space, and the four large manholes and handholes make cleaning easy. The cleaning doors are conveniently located in front and back and as the heater may be made right or left handed by turning half way around, it will fit into the plant without complications in the piping.

The oil separator is made in two types; one is extra large and fitted with a cutout valve, which permits of shutting off the body of the heater for cleaning without interfering with the action of the oil separator.

The second or standard oil separator permits of piping the heater on the thoroughfare or induction principle and eliminates oil from as much exhaust steam as is required for feed-water heating.

A steam trap and return openings are provided so that the heater may receive the returns from a steam-heating system or not as desired.

Lytton Vacuum Traps Serving Surface Condenser

When an engineer thinks of a surface condenser, he naturally associates with it a circulating and wet-vacuum pump, or a hotwell and dry-air pump. But how many have seen the wet-air pump used as a dry-air pump and the condensate from the condenser handled by one or more vacuum traps?

Although such a combination may appear impracticable, there may be seen in operation day and night, at the Jacob Ruppert Brewery, East Ninety-second St., New York City, either one of the two 1200-hp. Wheeler surface condensers, each piped to an Edwards air pump and two Lytton vacuum traps.

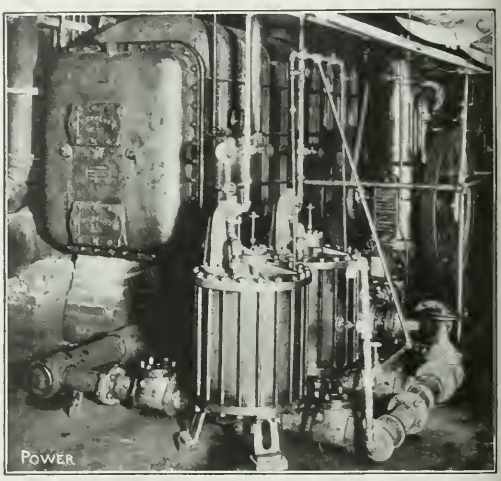
The conditions in this plant are different from those found in the average power plant. It is a refrigerating installation, with auxiliary lighting units. Beside cooling the products of the brewery, ice is manufactured for commercial use, and the problem was how to save the condensate from the surface condensers for making ice.

Originally the condensate was handled by the wet-air pump, but this so mixed the water, air and gas which entered the condenser that the water was worthless for manufacturing ice without further treatment. Various schemes were tried to free the water of air and gas, but without success, until the idea of adopting vacuum traps as a means of handling the condensate was adopted.

The two surface condensers in this plant each contain 1665 three-quarter-inch tubes, 10 ft. 2 in. long. The Edwards wet-air pump was piped to the condenser with a 6-in. nipple extending 4 in. above the bottom of the shell. The two traps were connected to the other end of the condenser at the bottom so that the water flows to them with a small head.

If for any reason both of the traps should fail to operate, the water would collect in the bottom of the condenser shell until it overflowed the top of the projecting 4 in., of the nipple of the air-pump connection. Should this occur, the pump operates as a wet-air pump and would maintain the vacuum and relieve the condenser of water. Under ordinary conditions the pump takes care of the vapor which is not condensed and stands ready to act as an emergency wet-air pump if necessary.

The accompanying illustration shows one of the con-



LYTTON VACUUM TRAPS OPERATING WITH A SURFACE CONDENSER

densers, the air pump and vacuum traps. Each trap operates at 80 lb. of water per discharge and, when both are in operation, discharges occur between four and six times per minute, depending upon the load on the engine. If for any reason one trap is out of service the remaining trap will operate at a rate of five discharges per minute, but such rapid and severe work is not recommended.

At the time a POWER representative saw the installation, each trap was discharging twice a minute. The trap gage showed a difference in pressure from 1 lb. to 28 in. of vacuum, which represented the discharge pressure and the vacuum on the trap during the discharge and filling periods. The traps are each 24 in. in diameter and 36 in. high. They operate with a consumption of 0.15 lb. of steam per 100 lb. of water discharged. The circulating water enters the condenser at 76 deg., and the outlet temperature is 86 deg. F. The condensate discharged by the trap has a temperature of 86 deg. F.

As the patent arrangements relating to this trap have not been fully made, details of the internal construction cannot be shown, but it is said to be extremely simple.

American Water Works & Guarantee Co.'s Report

The above company has issued a 60-page annual report containing about 110 illustrations, seven maps and seven pages of statements of constituent companies. The booklet is divided into five sections, representing the company's interests throughout 17 states from the Atlantic to the Pacific, water works, electric railway and power, irrigation, hydro-electric power and industrial.

The latest available information about the properties controlled and operated and about the communities served is given at considerable length. Views in cities having 30 water companies; of the West Penn Traction system and industrial establishments operated in whole or in part by electric power; of irrigation systems in Idaho and California, together with agricultural scenes; of power plants and sites in Idaho, and progress pictures of the Cheat River hydro-electric development in West Virginia; of properties of the United Coal Co. The frontispiece is a picture of Great Shoshone Falls, on the Snake River, near Twin Falls, Idaho. These falls are 212 ft. high, or 55 ft. higher than Niagara, and have been popularly pronounced the most beautiful on the American continent. The maps show locations of the properties and give a general idea of the scope of operations of the parent organization. The booklet is being distributed by J. S. & W. S. Kuhn, Inc., of Pittsburgh, the fiscal agent of the American Water Works & Guarantee Co.

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Exhibition of Power-Plant Specialties at Owen Sound

An exhibit of power-plant specialties and equipment will be held at Owen Sound, Ont., Tuesday, Wednesday and Thursday, July 29, 30 and 31, under the auspices of the Exhibitors' Association of C.A.S.E., when the stationary engineers meet in convention. An interesting program has been prepared for the convention and entertainment for ladies provided, including automobile trips, boat trips, etc.

The headquarters for the exhibitors will be King's Royal Hotel, at King's Royal Park, about two miles from Owen Sound.

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To Aid Exhibitors at the Panama-Pacific Exhibition

In corresponding with manufacturers of machinery and mechanical devices with reference to exhibiting at the Panama-Pacific International Exposition in San Francisco in 1915, the replies indicate that some manufacturers who build minor devices, although of great interest from an exhibit standpoint, cannot bear the expense of maintaining an individual representative in San Francisco during the Exposition period. The department of machinery exhibits will gladly coöperate with such manufacturers to make it possible for them to show their lines at reduced cost in accordance with the following suggestion:

If several such manufacturers will club together and make their individual applications for space for showing their products, and express their desire to have it done, they will be assigned space in such a way that their exhibits may be grouped together, and handled and cared for by one person; in this way the expense can be greatly reduced and the effectiveness of the exhibit enhanced. If this is done, each exhibit will be considered by the jury for awards in the same manner as if handled independently. It would perhaps not be wise to include in any group directly competitive articles, but it should be possible to work out groups of devices which are more or less related to each other, and yet do not come into direct competition.

As a concrete example, take a manufacturer whose work is confined almost exclusively to the making of ball bearings. An exhibit in which the ball bearings of all different forms and styles constituted the central feature might have grouped around it a number of other devices or machines in which the ball bearings are used, such as ball-bearing jacks, etc.

Similarly accessories of correlated kinds might be grouped together and the individual expense reduced.

The department of machinery exhibits will be pleased to hear from any persons who are interested in such a plan, and will cheerfully furnish any information possible to aid or assist intending exhibitors.

BOOKS RECEIVED

THE FITTING AND ERECTING OF ENGINES. By C. Leslie Browne. Emmot & Co., Ltd., Manchester, England. Cloth; 153 pages, 5¾x8¾ in.; illustrated. Price 3s. 6d.

PRACTICAL ALTERNATING CURRENTS. Fifth edition. By Chas. F. Smith. The Scientific Publishing Co., Manchester, England. Cloth; 398 pages, 5½x8½ in.; 258 illustrations; tables. Price 6 shillings.

ENGINEERING TABLES AND DATA. By W. W. F. Pullen. Third edition. The Scientific Publishing Co., Manchester, England. Cloth; 68 pages, 5½x8½ in.; tables; illustrated. Price 1s. 6d.

LOGARITHMS FOR BEGINNERS. Fourth edition. By Charles N. Pickworth. D. Van Nostrand Co., New York. Cloth; 49 pages, 5x7¼ in.; tables. Price 1 shilling.

STEAM POWER PLANT ENGINEERING. Fourth edition. By G. E. Gebhardt. John Wiley & Sons, Inc., New York. Cloth; 989 pages, 6x9¼ in.; 608 illustrations; chart. Price $4.

THE NEW STEAM TABLES. By C. A. M. Smith and A. G. Warren. D. Van Nostrand Co., New York. Cloth; 101 pages, 5½x8½ in.; plate; tables. Price, $1.25.

THE MOTOR AND THE DYNAMO. By James L. Arnold. The Chemical Publishing Co., Easton, Penn. Cloth; 178 pages, 6x9 in.; 166 illustrations. Price, $1.50.

GAS ENGINES AND PRODUCERS. By Lionel S. Marks and Samuel S. Wyer. American School of Correspondence, Chicago, Ill. Cloth; 62 pages, 5½x8½ in.; illustrated.

NEW PUBLICATIONS

PRACTICAL MATHEMATICS. By Claude Irwin Palmer, Assistant professor of mathematics, Armour Institute of Technology. Published by McGraw-Hill Book Co., New York. Size 4½x7 in.; 147 pages, illustrated, cloth. Price $1.75.

This volume treating the subject of trigonometry and logarithms is the last of a series of four volumes on the subject of Practical Mathematics. The other three volumes deal with arithmetic, geometry and algebra respectively.

The series is the outgrowth of a course in practical mathematics given in the evening classes of the Armour Institute of Technology. The purpose of these volumes is to present to the ordinary tradesman the means for obtaining a working knowledge of the mathematics he requires in his work. Numerous practical examples are used as a means of presenting methods for working in the various branches of mathematics covered by the series.

A PRIMER OF THE INTERNAL COMBUSTION ENGINE. By N. E. Wimperis. Published by D. Van Nostrand Co., 25 Park Place, New York City. Cloth, 5x7 in.; 143 pages, illustrated. Price, $1, net.

As the author states at the outset, this little book is intended chiefly as an introduction to his textbook on "The Internal Combustion Engine." In this way the larger work is not encumbered with the more elementary considerations, and those who do not care to go deeply into the subject will find sufficient in the "Primer" to give them a general knowledge of internal-combustion engines.

An introductory chapter is devoted to a brief history of the internal-combustion engine, and this is followed by chapters on the theory of heat, gases and vapors, the ideal engine, the real engine, fuels and gas producers, engine details and engine tests. Of course, only the high points are touched under each item.

The text has been prepared with a view to its use in the classroom, which fact explains the employment of calculus in the chapter on gases and vapors. Numerous examples are also included and the answers are given at the back of the book.

GAS ENGINES AND PRODUCERS. By L. S. Marks and S. S. Wyer. Published by the American School of Correspondence, Chicago, 1913. Size 8x5½ in.; 213 pages, illustrated. Price $1 net.

This is one of a list of handbooks which the American School of Correspondence has got out for home study to meet the needs of those who do not find it convenient to take the correspondence course. The book comprises two principal divisions—the first dealing with gas and oil engines prepared by Prof. Marks of Harvard and the second on gas

producers by Samuel S. Wyer, the well known authority on that subject.

No attempt has been made to go deeply into the mathematics of the subject, outside of a simple treatment of the thermodynamics of the Otto cycle; nor have the finer points of design been taken up—an omission very commendable in a book of that kind. Instead, the text is largely descriptive and in this respect undoubtedly covers more types of engines and producers than any other book of its size. Owing to the importance of the Diesel and semi-Diesel engines, however, we believe the authors could have profitably devoted more space to these types. There appears a slight repetition concerning gas engine fuels and producers in general as these are covered in both the gas engine and producer sections. This is probably due, however, to these sections being prepared by different authors.

Briefly, the main divisions of the subjects covered are: A historical sketch of the internal-combustion engine, the modern gas engine including valves and valve gears, thermodynamics of the Otto cycle, ignition, governing, starting, water jackets, large gas engines, kerosene and crude-oil engines, manufacture of producer gas, gasification losses and producer testing, representative types of producer-gas cleaning and producer-gas power plants.

The text is written in a simple but interesting style and is well illustrated. A careful perusal of the book should afford one a very good knowledge of the subject in general.

THE D'ESTE STEAM ENGINEER'S MANUAL. By Julian D'Este with an Electrical Appendix by Charles Penrose. Published by the Julian D'Este Co., 24 Canal St., Boston, 1913. Size, 5x7 in.; 493 pages, flexible leather. Price, $2 net.

This, the second edition of the manual, embodies much new matter not found in the original edition and besides, an electrical appendix of 356 pages. Although the electrical part takes up more space than that devoted to steam engineering, the title is not as misleading as might appear at first glance, for the electrical matter has been selected largely to meet the needs of the steam engineer.

The first part of the book is devoted to a brief review of mathematics and contains numerous useful tables and formulas. Very useful information is given on boiler settings, evaporative tests, pumps, the care of steam boilers and setting up stationary engines. Also, the engineer is shown how to figure riveted joints, the strength of boiler shells, strength of stays, bursting stresses in flywheels, areas of safety valves, etc.

It is to be regretted that the author, in revising the work did not incorporate the Marks and Davis steam tables instead of adhering to the old values and he might well have given more space to the broad subject of internal-combustion engines, and to mechanical refrigeration and ice-making, especially since a great many steam plants now contain refrigerating machinery.

The electrical matter is excellent and contains just the information that the operating man desires regarding the care and operation of the usual electrical apparatus. In this the numerous wiring diagrams should prove helpful. Chapters are also devoted to thermo-electric pyrometry, standard cells, measurements of electromotive force and illumination.

About 50 pages are devoted to illustrating electrical generating machinery and another 30 pages to views of typical generating stations in the United States. This is followed by a synopsis of the electrical equipment of a typical alternating-current generating station.

The book should prove a valuable aid to the operating engineer.

SOCIETY NOTES

It has been decided to make the Hotel Schenley the headquarters of the Illuminating Engineering Society convention, which will be held in Pitsburgh, Sept. 22-26. The hotel is in a popular residence section, within easy walking distance of the Carnegie Museum, the Library, Carnegie Technical Schools, University of Pittsburgh, several prominent clubs and the Soldiers Memorial Hall. The last-mentioned building will prove of particular interest to illuminating engineers because of its wonderful lighting, said to be unequalled anywhere in the United States.

The program as now outlined covers an exceedingly interesting set of papers on illumination.

In addition to the technical sessions, the local committee has arranged for a series of entertainment features, in which the ladies are included, covering golf, tennis, baseball games, automobile rides, theater and card parties, and conclude with a banquet at Hotel Schenley, at which some innovations are promised.

Inspection trips have been arranged to several industrial plants including the Westinghouse Electric & Manufacturing Co., Macbeth Evans Glass Co., and the Carnegie Steel Co.; also a luncheon at the H. J. Heinze Co., the home of the 57 varieties, for the ladies.

The papers as now scheduled include, among subjects, the "Quartz Light, Fontune, and Neon Tube"; "Church, Factory, Store, Hospital and Street Car Lighting"; "The Present Commercial Development in Several Forms of Lighting"; "Errors in Photometric Measurement," and the "History of Artificial Lighting."

The development of the new flame-carbon arc lamp will also be discussed by representatives of the manufacturing concerns.

An interesting feature of the technical sessions will be the holding of symposiums on the various general subjects to be led by those particularly well posted. These meetings will afford open discussion.

A transportation committee has been appointed, including the secretary of the local section in each city, which will perfect arrangements for the members and friends in obtaining transportation to and from Pittsburgh.

The sixth annual excursion of the Combined Association of Engineers of Brooklyn, N. Y., took place on Sunday, July 13. About 2000 engineers and their friends boarded the steamboat "Adonis" and barge "Sparina" from Jewell's wharf. A sail of 40 miles up the Hudson River was made, during which dancing was enjoyed. The excursionists stopped at Forest View Grove, returning to Brooklyn at eight o'clock. The several committees are to be congratulated.

PERSONALS

J. F. Nagle, chief engineer of the Kenogami and Jonquiere Paper Mills of Price Brothers & Co., and lately chief inspector for the New York Steam Co., has been promoted to the position of supervisor of power plants for the above company with headquarters at Kenogami, P. Q., Canada.

B. S. Rederer has opened an office at 518 Park Building, Pittsburgh, Penn., for the sale of power-plant equipment. He will represent the Brownell Co., Dayton, Ohio, W. K. Mitchell & Co., Inc., Philadelphia, Penn., Canton Grate Co., Canton, Ohio and the Burt Manufacturing Co., Akron, Ohio.

C. V. Kerr, formerly chief engineer for McEwen Bros., Wellsville, N. Y., has severed his connection with that company after 3½ years' work in developing a helical pump and a propellor blower. He is now engaged in the private development of a group of turbine-driven power-plant auxiliaries.

Dean W. F. M. Goss, of the College of Engineering, University of Illinois, has been unanimously elected chief engineer of the committee on smoke abatement and electrification of railway terminals of the Chicago Association of Commerce. Dean Goss will succeed Horace G. Burt, who died recently. In order that he may take up the work without interruption, he has had granted to him by the University of Illinois a leave of absence for a year.

John F. Duffey, treasurer of the Scandinavia Belting Co., has just returned from a month's trip abroad having visited the company's mills at Yorkshire, England. Mr. Duffey reports that the large volume of business this company has enjoyed has compelled extensive additions to the present works, making the third within the last five years. Mr. Duffey also states that the policy of the Scandinavia Company is such that the factory help is given many comforts, such as recreation grounds, etc., a large dance hall and employees' dining room being a part of the factory. The office in London occupies four floors devoted exclusively to the selling of textile beltings. The factory equipment is of the latest type.

OBITUARY

William Finney, head of the boiler manufacturing concern of Finney & Hoffman, died at his home in Brooklyn, N. Y., on July 7. Mr. Finney was 81 years of age.

POWER

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A man on the job—ready for any emergency—fully aquainted with every piece of machinery in his charge—fully alive to the possibility of his department.

A man who runs his plant intelligently, so that every dollar spent in his department yields a dollar's worth of value and maybe more.

A man who knows that his department is operated on as economical a basis as is possible with modern equipment.

A man who is not worried by central station figures—who knows he can hold his own.

A man who can prove to his boss at any time that he is the right man for his job.

A man who goes about his work with a smile, who handles his men with a smile, who is master of himself and his future, who takes advantage of every opportunity to add to his knowledge of power engineering—who knows things, in other words, instead of guessing—who does things instead of wondering how to do them.

That man is a live wire.

Do you do your work with a confident smile? Are you a live wire? Be one!

Savannah Electric Co.'s New Power Plant

BY WARREN O. ROGERS

SYNOPSIS—The new, 11,500-kw. capacity, steam-turbine central station is probably one of the most up-to-date installations in the South. It will displace the old reciprocating-engine, belt-driven units of the old plant. The boilers are on a floor above the turbines, and are separated from them by a brick wall. Controlling switches, electrical recording instruments, etc., are on galleries on the opposite side of the turbine room.

In order to economically supply the demand for electrical energy in the City of Savannah, Ga., which has outgrown the capacity of the old plant, a new, modern installation has been built and put into operation.

The old plant was, at one time, a good example of the modern central station of its period, and that not so many years ago. The generators were belt driven from

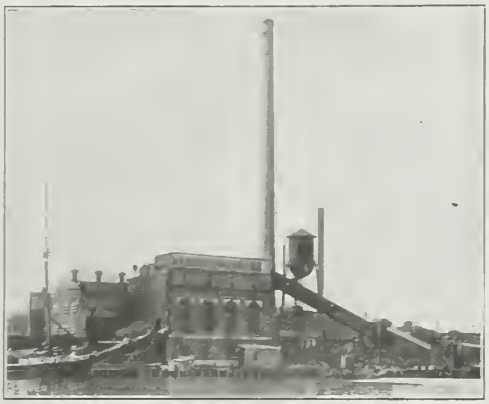


FIG. 1. VIEW OF THE SAVANNAH ELECTRIC CO.'S NEW POWER PLANT FROM THE RIVER

reciprocating engines, and both return-tubular and water-tube boilers were used. The switchboard and controlling apparatus, then modern, are now out of date. Most of the electrical apparatus has been removed and all electrical energy generated by the company will soon be sent out from the new plant.

Savannah, like several other Southern cities, has two electric-lighting companies, and as a result, competition has made the price to users of electrical energy considerably below that of cities where but one company supplies the demand. It is understood that the price ranges from 6c. per kilowatt-hour down.

The new plant is located on the banks of the Savannah River, Fig. 1. It is a brick building and the general interior design attracts the eye at first glance. Entering the building from the street, one steps into a hall, off of which the chief engineer's office is located. A stairway leads from the inner end of the hall to the lower or switchboard gallery, on the right-hand side of the plant. Above this gallery is a second, used for purposes to be described later. Both of these galleries open on the turbine room. On the opposite side of the plant is a bay on a level with the turbine floor, which extends under the boiler setting. Beyond the dividing wall of the bay is an ashroom, above which is the boiler-room firing alley. Between the ashroom and the bay in the turbine room is the brick setting of the boiler ashpits. One end of the boiler and turbine room is made with temporary walls to allow further extension of the plant when the demand justifies such action.

Upon entering the turbine room, the visitor obtains a general view of the generating units, consisting of two 5000-kw. and one 1000-kw. turbine units. The turbines operate with 180 lb. steam pressure superheated 125 deg. Both large units run condensing at 1800 r.p.m. The generators of these turbines are of 6250 kv.-a. capacity, and produce two-phase, 60-cycle current at 2300 volts. The 1000-kw. turbine drives a 1250-kv.-a. generator.

Contrary to common practice, the condensers, instead of being in a basement or condenser pit are on the floor level with the turbines. All auxiliary units are also on the same floor level. This arrangement brings all of the units of each main generator where their operation is under the immediate observation of the man on watch, and also renders the crane available so that repairs or inspections can be made most expeditiously.

The turbines are placed crosswise of the room and the surface condenser and circulating-pump units are beside them. A general view of the turbine room is shown in Fig. 2. The arrangement of the surface condensers and other auxiliary machinery is also shown. Fig. 3 shows a plan and elevation of the entire plant.

Each large surface condenser contains 13,000 sq.ft. of cooling area. The small condenser has 4000 sq.ft. of cooling surface; all condensers are of the horizontal type.

Circulating water is obtained from the Savannah River and is supplied to the large condensers by two 18-in. volute pumps, directly connected to 11x12-in. vertical steam engines. The small condenser is supplied with circulating water by a 10-in. volute pump directly connected to a 6x7-in. vertical steam engine.

On the turbine floor at the end of each of the larger water-circulating units is a vertical steam turbine directly connected to a centrifugal hotwell pump; running at 2000 r.p.m.

The dry-vacuum pumps operating in connection with the large condensers are placed at the head of each unit. They are 10 and 26 by 18 in. in size. The small vacuum pump is 8 and 16 by 12 in. in size.

EXCITER UNITS AND GAGE BOARDS

Two exciter units are driven by 125-kw. horizontal steam turbines at 2400 r.p.m. and run noncondensing. Each turbine is directly connected to a direct-current generator of 1000 amperes capacity, at 125 volts. The vacuum pumps and exciter units are on the south side of the plant.

At the head of each turbine is a gage board upon which are mounted a frequency meter, an indicating steam gage, an indicating spring-vacuum gage, an absolute mercury-pressure gage, a recording steam-temperature gage to show the temperature of the inlet steam and a record-

ng vacuum gage connected to the exhaust to the condenser. The gage boards for the two larger turbines also contain a spring gage which indicates the pressure in the first stage of the turbine.

Pumps

Fig. 3 shows the location of the pump bay; a near view of the pump units is shown in Fig. 4. They consist of a 16 and 10 by 18-in. pot valve, outside-center packed, duplex, boiler-feed pump; one 7½ and 4½ by 6-in., duplex, outside-end packed, pot-valve pump, used for boiler feed, and one turbine-driven unit, the water end of which is a 4-in., four-stage, centrifugal pump, also motor-generator set for supplying railway current. The synchronous motor is of 1450 hp. capacity, using 2300-volt, 60-cycle current, and is built for 80 per cent. power factor leading current. The generator end delivers 600-volt current and is of 1667 amperes capacity, at a speed of 514 r.p.m.

A study of the turbine room shows that ample space has been provided about each unit which will greatly facilitate the work necessary about the plant when repairs are made. The floor is of concrete. The roof is also of concrete with tar and gravel covering supported by steel roof trusses carried on the main building. A 45-ton crane serves the entire area of the turbine room.

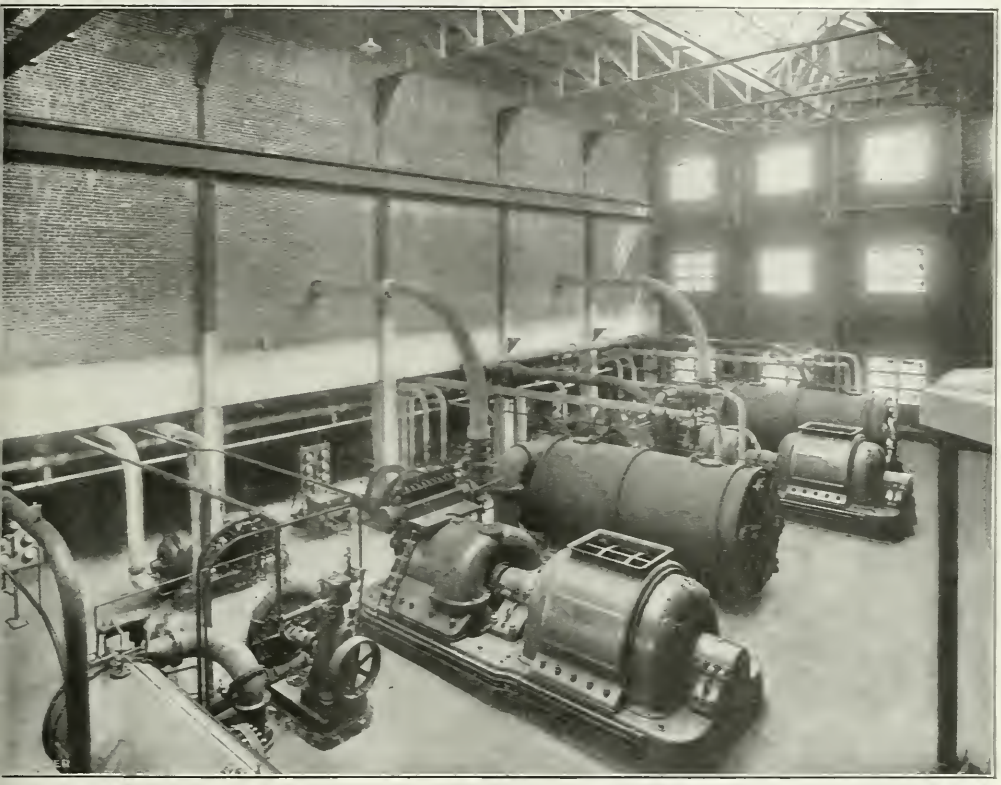


Fig. 2. General View of the Turbine Room

used for boiler feed. This gives a flexible means of supplying boiler-feed water. A 7½ and 8½ by 10-in., piston-pattern, duplex pump is used for low-service duty. A 3-in., 1755-r.p.m., single-stage centrifugal pump is directly coupled to a 15-hp., two-phase, 220-volt induction motor. This is used for pumping water to the elevated tank and for other station uses. This pump is normally operated continuously but is relayed by the 7½ and 8½ by 10-in. steam-driven pump already mentioned.

A small 1½-hp., motor-driven, 1½-in. centrifugal pump handles the raw water supplied to the settling and filtering tanks.

At the end of the room next to the small turbine, is a

Boiler Room

The arrangement of the boilers is of interest, in that the greater part of the ground area beneath them is used to advantage for purposes other than that of ashpits. The floor space devoted to pumps is in the bay under the rear end of the boilers and gives just that much more floor area to the turbine room. All headers and pipe connections are either placed back of the boilers in the boiler room or are suspended from the ceiling of the pump bay.

There are four 708-hp., three-drum water-tube boilers, each equipped with superheaters which superheat the steam 125 deg. F. The boilers each have 294 four-inch

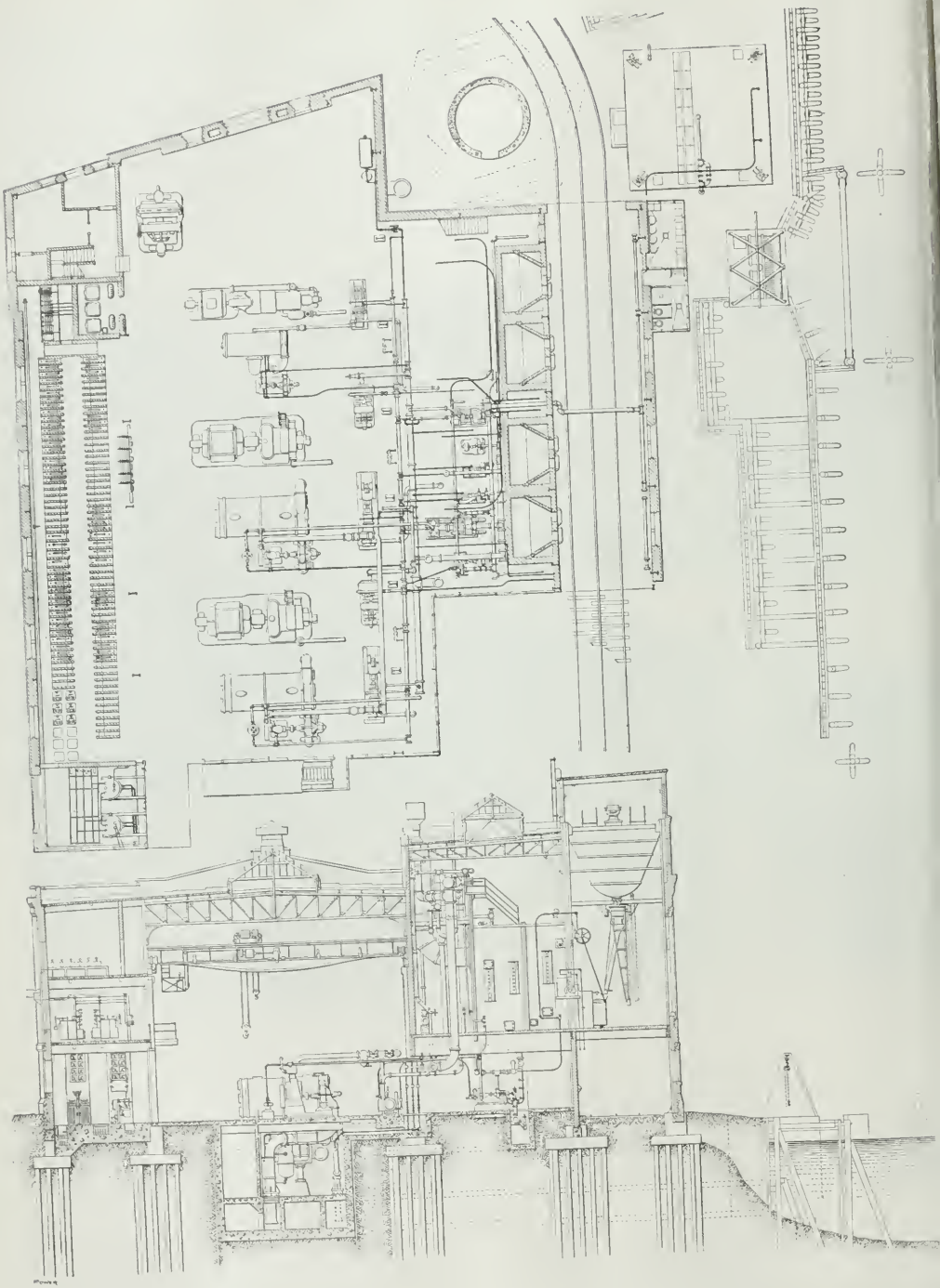


Fig. 3. Plan and Elevation of the Savannah Power Plant

ubes, 20 ft. long, and three 42-in. drums made of ½-in. plate; they are 22 ft. 3 in. long, and are made of open-earth steel having a tensile strength of 56,000 lb. The boilers are designed for 200 lb. steam pressure. Steam is measured by steam-flow meters, one for each boiler.

Chain-grate stokers, each 11x12 ft., or 132 sq.ft. of active grate area, are used. They are driven by eccentric and rods from an overhead shaft hung from brackets on

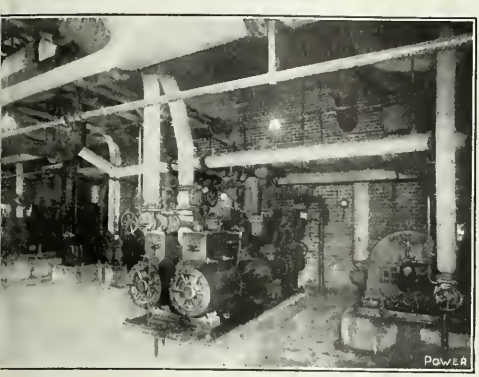


FIG. 4. PARTIAL VIEW OF THE PUMP ROOM

the front of the boilers. The shaft is belt driven by either of two vertical steam engines, one placed between the two batteries of boilers, the other at the end of the second battery next to the temporary end partition. The shaft is provided with a clutch at each belt wheel, so that a section of the shafting can be cut out if desirable, or each battery of boilers can be operated independent of the other stoker engine. A partial view of the boiler room from the front is shown in Fig. 5.

Coal is delivered to the stokers from a 320-ton capacity, steel, concrete-lined, suspended coal bin, parabolic in shape. It extends the length of the boiler room and holds several days' supply of fuel. The concrete lining protects the steel casing from any corrosive action of the coal. A coal chute, equipped with a weigher, travels on a track suspended from the under side of the storage bin. The weigher is filled from either one of the four outlets in the storage bin, and the fuel is delivered to the stoker hoppers after being weighed.

Fuel is usually brought to the plant in vessels, and either unloaded on a pile near the wharf by a tub hoist, or is hoisted and dumped into a hopper above the crushing rolls, from which it falls onto a belt coal conveyor, running on an incline from the coal crusher on the wharf to a point central with the storage bin in the boiler house. Here it discharges the coal onto a second belt conveyor running at right angles to the first, by which the fuel is delivered to the coal bunker. In case no cargo is to be unloaded, the necessary fuel to keep the plant in operation is hoisted from the storage pile in the yard and dumped into the crusher, and conveyed to the coal-storage bin over the boilers. Rail coal can also be handled.

A view over the top of the boilers is shown in Fig. 6. The tops of the boilers have been filled in level, so that there is a smooth, flat surface, with the exception of the pipe connections and the pockets made for convenience in getting at the top row of tubes through doors at the bottom of the clean-out spaces, two of which are shown in the foreground of Fig. 6. All piping above the boilers is shown, and its simplicity contrasts with the array found in many boiler installations. There are three pop safety valves for each boiler, two on the saturated-steam pipes and one on the superheated-steam connection.

Feed water can be drawn from the open heater, seen at the right-hand corner of Fig. 6, and pumped to the boilers through either a 6-in. main feed line feeding in at the front of the drum, or through an auxiliary 1½-in. feed line at the rear. Due to the elevated position of the heater, the water goes to the feed pumps by gravity. In case of emergency the water can be cut out and water drawn directly from the river. A covered steel smoke flue runs along the rear ends and above the setting of the boilers. A smoke uptake from each boiler connects with the bottom of the main smoke flue, as shown in Fig. 7. The draft is controlled by a damper regulator, the damper being placed in the smoke flue between the boiler and the reinforced-concrete chimney, which is 10 ft. inside diameter at the top and is 253 ft. 6 in. high.

FIG. 5. FRONT OF BOILERS

FIG. 6. SETTING OVER BOILERS

FIG. 7. BACK OF BOILERS

The 3-in. blowoff header, Fig. 7, has three connections to each boiler, with a blowoff valve between the boiler and the fitting in the header. At the end of the header an angle valve connects with a vertical blowoff pipe, as shown.

PIPING

Steam is conveyed from the boiler to the 12-in. main steam header at the rear of the boilers through four 6-in. long-radius bent pipes which run in a horizontal di-

rection above the boilers and then drop vertically to the header, as shown in Figs. 6 and 7. This header rests on roller saddles, about 3 ft. above the boiler-room floor. A U-expansion bend is connected to the header at the far end, just beyond the last boiler. This position will bring

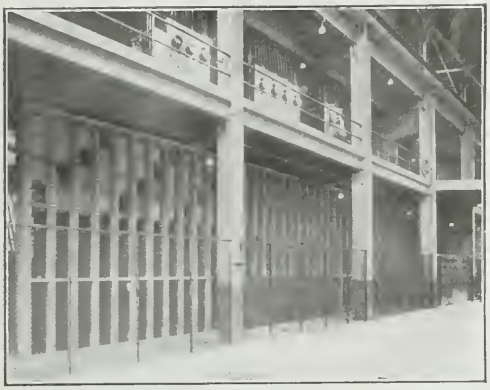


FIG. 8. SWITCHBOARD GALLERY AND BUSBAR COMPARTMENTS

it in the center of the header when duplicate boiler units have been installed.

The steam pipes leading from the boilers to the header are fitted with two stop valves, one automatic nonreturn valve close to the boiler outlet, the other just above the header. A gate valve in the header permits of cutting out one-half of the header, two boilers supplying steam to each half, if necessary. The main 12-in. header is connected to the auxiliary 6-in. header, hung from the ceiling of the pump bay, by a 6-in. pipe connecting at each end of the header. Both are piped from the top of the main header and, making a U-bend, drop through the floor to the auxiliary header. All valves and fittings in the superheated-steam piping system are of openhearth steel.

All main turbine units are piped directly to the main 12-in. header. The small 1000-kw. unit is supplied with steam through a 6-in. long-radius bent pipe; the two large turbines through an 8-in. long-radius pipe, as shown in Fig. 2. These connections are made from the top of the header through an angle valve, thus avoiding pockets for the accumulation of water when the units are shut down, Fig. 7.

Steam for the auxiliaries is taken from the top of the auxiliary 6-in. header, and extended in either direction horizontally to the various pumps, etc., dropping with short-radius bends, as shown in Figs. 3 and 4.

An exhaust-steam header is also hung from the ceiling of the pump-room bay. It begins with 8 in. at the end next to a small air compressor at an end of the bay and is enlarged to 14 in. at the other end. A 16-in. pipe beyond the vertical 20-in. connection to the heater permits of handling exhaust steam from future auxiliary units. The 20-in. exhaust pipe runs to the heater, which can be bypassed, the exhaust steam escaping to the atmosphere through a 16-in. horizontal back-pressure valve. The live-steam piping is drained through a drip header to the Holly receiver and discharge chamber and the water returned to the boilers by gravity.

Makeup feed water for boiler use is taken from the Savannah River. On account of the muddy condition of the water, it is first admitted to a fluctuating tank placed below the ground level, into which a coagulating solution is pumped. When the mud has been precipitated, the water goes through a filter into a storage tank from which it is pumped to the feed-water heater.

Notwithstanding that the arrangement of the various units has been such that ample floor room has been provided around them, the same liberal space has been devoted to the electrical-controlling devices, etc.

PRINCIPAL EQUIPMENT OF THE SAVANNAH ELECTRIC CO.'S NEW POWER PLANT

No.	Equipment	Type	Purpose	Kv.a	Kw	Phase	Cycles	Volts	Amp.	Hp.	R.p.m.	Size	Steam Press. Lb.	Manufacturers
1	Turbine	Horizontal			1000						1800		180	Allis-Chalmers Co.
2	Turbines	Horizontal			5000						1800		180	General Electric Co.
1	Generator	Alt. current	Main units	1250		2	60	2300			1800			Allis-Chalmers Co.
2	Generators	Alt. current		6250		2	60	2300			1800			General Electric Co.
1	Condenser	Surface										4000 sq ft		Henry R Worthington
2	Condensers											13,000 sq ft.		
1	Pump	Volute	Circ. water								300	10″		
2	Pumps										225	18″		B. F. Sturtevant Co.
1	Engine	Vertical	Circ. pumps								330	6x7″	180	
2	Engines										225	11x12″	180	
2	Turbines	Vertical	Hot-well pumps								2090		180	Terry Steam Turbine Co.
1	Pump	Horizontal	Dry air								100	8x16x12″	180	Henry R Worthington
2	Pumps										100	10x26x18″	180	
2	Turbines	Horizontal	Exciter units		125						2400		180	General Electric Co.
2	Generators	Direct current			125			125	1000		2400			
1	Pump	Pot valve	Boiler feed									16x10x18″	180	Henry R. Worthington
1	Pump	End packed										7½x4½x6″	180	
1	Turbin	Curtis											180	General Electric Co.
1	Pump	Four-stage										4″		Alberger Pump & Condenser Co.
1	Pump	Duplex	Low service										180	Henry R. Worthington
1	Pump	Centrifugal									175	2″		
1	Motor	Induction	Centrifugal pump			2	60	220		15	1800			
1	Motor-generator	Synchronous	Motor service			2	60	2300 / 600	1667	1450	514			General Electric Co.
1	Crane	Case	Turbine room									45 tons		Case Crane Co.
4	Boilers	Water tube	Steam gen.							708			180	Babcock & Wilcox Co.
4	Superheaters	Foster	Steam											Power Specialty Co.
4	Meters	Steam flow	Steam											General Electric Co.
4	Stokers	Chain grates	Furnace									132 sq.ft.		Green Engineering Co.
1	Conveyor	Belt	Coal											Robins Conveying Belt Co.
12	Valves	Safety	Pop											Ashton Valve Co.
1	Heater	Open	Feedwater											Exeter Machine Wks.
	Switchboards	Panel	Elec. control											General Electric Co.

ELECTRICAL APPARATUS

The main distributing switchboard and the benchboard for control of generating and converting equipment are on the first gallery opposite the boiler room, as shown in Fig. 8. A double 2300-volt bus in concrete and brick

compartments is located over the oil switches in the bay below the switchboard gallery. The bus structure is in two rows, at the end of which are located the feeder regulators.

The five-panel switchboard shown at the right of Fig. 8 on the generator floor controls the station lighting and power service. Fifteen mercury arc sections for street lights are located in the switchboard gallery.

On the top balcony the turbine-field rheostats are placed, with provision for four more. This floor also affords room for a storage battery for operating the solenoid control switches in the station. A projection, central with the length of the switchboard gallery, affords means for the operator to obtain a view of the entire turbine room. The balconies and floor of the boiler and turbine room are of concrete. The building is well illuminated, both by natural light during the day and artificial illumination by night.

Distributing circuits are carried from the station overland with the exception of three line cables for operating two substations. These are taken out underground.

When the new substation, now nearing completion, is put into service, the electrical energy from the power plant will be transmitted to it in a duplicate underground line, there to be converted by motor generators for supplying an Edison three-wire system in the business district. This new building will contain the necessary converting apparatus and offices of the company. It is located in a district convenient for business and distributing purposes. This power plant was designed and constructed by the Stone & Webster Engineering Corporation, Boston, Mass.

The "Flat-Curve" Engine

By A. D. Skinner

SYNOPSIS—Valve leakage rather than increased cylinder condensation is the cause of greater steam consumption at light loads.

For years the astrologer's stone in steam engineering has been the "flat-curve" engine, i.e., an engine that would give the same steam consumption per indicated horsepower-hour over a wide range of load. The profession has become so used to curves that begin to mount up or show a "heel" at half load that they have begun to accept it as the result of a condition impossible of improvement, and have attributed the increased steam consumption at the light loads to cylinder condensation. An attempt will be made to prove that the cause of the much greater steam consumption at light loads is not increased cylinder condensation, but merely valve leakage.

Fig. 1 shows the economy obtained from a 13x15-in. Skinner engine, operating noncondensing, with a steam pressure of 104 lb. gage at the throttle, the speed of the engine being 268 r.p.m. Saturated steam was delivered at the throttle, having an average moisture of 2.2 per cent. by throttling calorimeter, which was allowed for

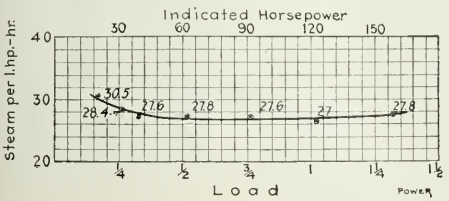


Fig. 1. Results from Flat-Curve Engine

in computing the net steam consumption. The tests were made by condensing the exhaust at atmospheric pressure in a surface condenser, and weighing the condensate. Several tests were made at the light loads to check the correctness of the former tests and to establish definitely the curve.

The valve was of the Skinner standard steam-tight type, and was proportioned to obtain the desired results. It was not reset or adjusted as to lap or lead during the entire series of tests.

The curve is remarkable for its flatness, and is unique in steam-engineering practice for any engine, whether single-valve or multiple-valve, as it shows practically the same steam consumption per indicated horsepower-hour from ¼ to 1¼ load inclusive. The usual textbook

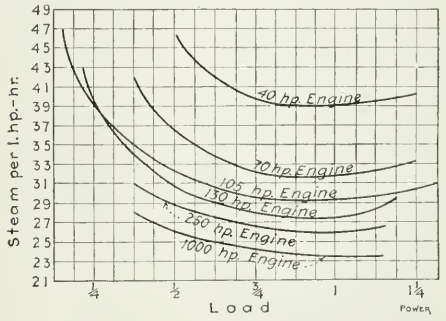


Fig. 2. Typical Rate Curves of High-Speed Engines

theories of cylinder condensation for light loads seem to be quite set at nought by the results of these tests.

Fig. 2 is reproduced from a widely read textbook on steam engines, for the reason that these curves are designated in this textbook as "typical economy curves of high-speed engines." These curves all show the usual heel at loads less than half.

Increased cylinder condensation, due to early cutoffs, assumes relatively little importance as compared with the steam-tight valve; and practically all tests to determine the amount of cylinder condensation have been based upon the performance of engines having leaky valves, whether these engines were single-valve or multiple-valve.

The builders of pressure-plate valve engines have until recently stated in their catalogs that there was 0.003-in. clearance between the valve and the housings. Therefore, there is an initial leakage, which, of course, increases

he longer the engine is operated. To prove these state-
ients, take the guarantees made recently by a prominent
ngine builder on a pressure-plate valve engine. This
ngine was of twice the capacity of the engine that pro-
uced the flat curve. The steam pressure was to be 90
)., whereas the flat-curve engine had a steam pressure
f 104 lb.; but the pressure-plate valve engine, being of
wice the capacity, had an advantage that is not offset
y the slightly lower steam pressure. Therefore, the econ-
mies of the two engines admit of a fair comparison:

Load	¼	½	¾	1
ressure-plate valve guaranty	40 9	33 2	30 2	29 8
lat-curve engine economy	28 4	27 8	27 6	27 0

It may be noticed that the steam consumption guaranty
nade for the pressure-plate valve engine is exactly 10
er cent. more at full load than the economy obtained
y the steam-tight valve engine. Now, the amount of
eakage through a valve on an engine may be regarded
s constant for all loads. As a matter of fact, it is some-
hat greater in amount at light loads, on account of
ss steam seal, due to early cutoffs, as well as for other
easons which need not be discussed here. But for this
ase it is favoring the pressure-plate valve engine to
ssume that it is constant; and the exponents of this type
f valve cannot complain when it is assumed for pur-
oses of demonstration, that a pressure-plate valve engine
f 120 hp. capacity at 104 lb. pressure (the same horse-
ower and pressure as for the flat-curve engine) will
ive just as good economy as was guaranteed for an en-
ine of twice its capacity at 90 lb.

The pressure-plate valve engine guaranty at full load
as 29.8 lb., or an hourly steam consumption of 3576
). for a 120-hp. engine. The flat-curve engine at full
oad of 120 hp. gave an economy of 27 lb. per i.hp.-hr.,
r an hourly consumption of 3240 lb. The difference,
36 lb., or about 10 per cent. of the amount of steam
upplied to the steam-tight valve engine, represents the
mount of steam leaking past the pressure-plate valve
ourly. Remembering that the amount of valve leak-
ge is practically constant for all loads, the processes in
Table 1 are worked out to show how this 336 lb. hourly
eakage affects the economy of the engine at various loads.

TABLE 1

FULL LOAD

7 lb. × 120 hp. = 3240 lb. per hr., no leakage.
240 + 336 lb. leakage = 3576 lb. per hr., with leakage
576 ÷ 120 hp. = 29 8 lb. per hp.-hr.

THREE-QUARTER LOAD

7 65 lb. × 90 hp. = 2488 lb. per hr., no leakage.
488 + 336 lb. leakage = 2824 lb. per hr., with leakage.
824 ÷ 90 hp. = 31 3 lb. per hp.-hr.

ONE-HALF LOAD

7 84 lb. × 60 hp. = 1670 lb. per hr., no leakage.
670 + 336 lb. leakage = 2006 lb. per hr., with leakage.
006 ÷ 60 hp. = 33 4 lb. per hp.-hr.

ONE-QUARTER LOAD

8 46 lb. × 30 hp. = 853 8 lb. per hr., no leakage.
53 8 + 336 lb. leakage = 1189 8 lb. per hr., with leakage
89 8 ÷ 30 hp. = 39 6 lb. per hp.-hr.

Compare, now, the flat-curve engine economies with
0 per cent. valve leakage added, as above determined,
ith the guaranteed economies of the pressure-plate valve
ngine. The rates are almost identical.

Loads	¼	½	¾	1
ressure-plate valve guaranty	40.9	33 2	30 2	29 8
lat-curve engine with 10 per cent. leakage	39 6	33.4	31 3	29.8

This comparison tends to show that valve leakage, not
ncreased cylinder condensation, is responsible for the
igh steam consumptions at under loads.

Curve *A*, Fig. 3, is the flat curve, reproduced from Fig.
1 for comparison. Curve *B* represents the economy the
flat-curve engine would have given if there had been 10
per cent. initial valve leakage at full load.

Pressure-plate valves, like piston valves and other types
of solid valves working in holes of solid metal, wear loose
instead of wearing tight, and the steam consumption in-
creases instead of lessening. Curve *C* shows the economy
of the pressure-plate valve engine with its initial valve
leakage of 10 per cent. at full load, and an additional
valve leakage of 10 per cent., due to wearing of valve
after not more than three months' operation. Table 2
shows the method of obtaining these amounts:

TABLE 2

Valve with 10 per cent. initial leakage, and 10 per cent. future leakage:

FULL LOAD

29 8 lb. × 120 hp. = 3576 lb. per hr.
3576 + 10 per cent. leakage (or 357 lb.) = 3933 lb. per hr
3933 ÷ 120 hp. = 32 7 lb. per hp.-hr.

THREE-QUARTER LOAD

31.3 lb. × 90 hp. = 2817 lb. per hr.
2817 + 357 lb = 3174 lb. per hr.
3174 ÷ 90 hp. = 35 2 lb. per hp.-hr.

ONE-HALF LOAD

33 4 lb. × 60 hp. = 2004 lb. per hr.
2004 + 357 lb. leakage = 2361 lb. per hr.
2361 ÷ 60 hp = 39.3 lb. per hp.-hr.

ONE-QUARTER LOAD

39 6 lb × 30 hp. = 1188 lb. per hr.
1188 + 357 lb. leakage = 1545 lb. per hr.
1545 ÷ 30 hp. = 51 5 lb. per hp -hr.

Twenty per cent. or more leakage after an engine has
been in operation only three months scarcely seems
credible, but a number of tests to prove this point might

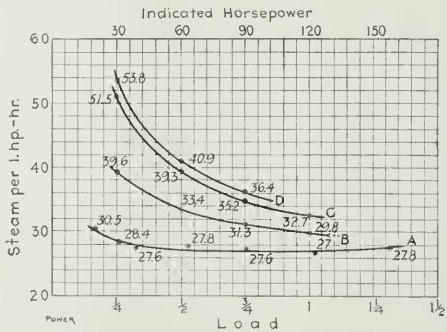


FIG. 3. A COMPARISON OF STEAM RATES

be cited: In Binghamton, N. Y., a 10x12-in. pressure-
plate valve engine was replaced on the coal-saving basis
by a steam-tight valve engine. The builders of the pres-
sure-plate valve engine were allowed to place this valve
in the most economical condition possible about three
months before the competitive test was made.

Both engines were tested out under identically the
same conditions, namely: 100 lb. steam by gage at the
throttle, 1 lb. back pressure above atmosphere, and at
82 per cent. load.

The pressure-plate valve engine showed a steam con-
sumption of 36.4 lb. per i.hp.-hr., and the steam-tight
valve engine 28.3 lb., a saving of 8.1 lb. per i.hp.-hr. The
valve leakage amounted to 27.5 per cent. at this load,
which is equivalent to 22.2 per cent. at the full rated load
of the engine.

The steam consumption per hour of the pressure-plate
valve engine was 1894 lb., while that of the steam-tight
valve engine was 1485 lb., or a leakage of 409 lb. per hr.,

irrespective of the load on the engine. Adding this 409 lb. steam leakage per hour to the actual hourly consumption of the steam-tight valve engine (remembering that this particular engine showed 0.7 lb. more steam per indicated horsepower per hour than the flat-curve engine) gives curve *D*, Fig. 3. In checking this curve, the fact must be borne in mind that the full-load rating of the Binghamton engine was 66 i.hp., instead of 120 i.hp., which was the full-load rating of the flat-curve engine.

As a proof that 36.4 lb. per i.hp.-hr. is not unusual for a pressure-plate valve engine, one more test on an engine of the same size and make as the Binghamton engine that had been in operation only three months, will be cited. This 10x12-in. pressure-plate valve engine showed a steam consumption of 37.8 lb. per i.hp.-hr. at full load. The engine operated under a steam pressure of 135 lb., which would tend to prove that the greater the pressure the greater the leakage past a balanced valve.

As a further proof that cylinder condensation does not increase enough to affect the economy of an engine, down to one-quarter load, tests might be cited that the author has made with superheated steam on steam-tight valve engines. The curve with superheat exactly parallels the curve with saturated steam, from full load to one-quarter load, showing that all that has been accomplished by the introduction of superheat has been to lessen the initial cylinder condensation which takes place to a greater or less extent in every engine, depending somewhat on the arrangement of valves.

Cylinder condensation, to which has been attributed the poor economy of engines at early cutoffs, should not be confused with initial cylinder condensation, which must occur with any engine using saturated steam. The former condensation is not perceptible at loads less than one-quarter, and with an initial steam pressure of 100 lb. To valve leakage not to increased cylinder condensation, should be charged the inefficiency of steam engines not employing steam-tight valves.

❋ ❋

Economy of Compression in Steam Engines

By Robert R. Fisher

SYNOPSIS—The conclusion from these tests, conducted at the Kansas State University, is that compression up to about 45 per cent. of the initial absolute steam pressure is advantageous. Above this point the economy decreases, the rate of decrease being more pronounced at light loads.

❋

Laboratory work on the economy of compression in the steam engine, so far as the author knows, has been done by only two men—the late Professor Dwelshauvers-Dery, of Liége, Brussels, and Prof. R. C. Carpenter, of Sibley College.

Professor Dwelshauvers-Dery, in 1875, carried on a series of experiments on an engine approximately 11.8x23.6 in. (See Power, June 28, 1910.) Runs were made with compression varying from 0 to 40 per cent. Two series of tests were made: one at 45 r.p.m. and the other at 60 r.p.m. The results of these tests showed increasing steam consumption with increasing compression.

A few years ago, Prof. R. C. Carpenter conducted a series of tests at Sibley College on the high-pressure cylinder of a triple-expansion engine. (See Power, Jan. 24, 1911.) Compression was carried from 42.8 to 87.2 per cent. of the initial pressure. These tests likewise showed increasing steam consumption with increasing compression.

In the spring of 1911 a series of tests were made at the mechanical laboratories of the Kansas State University, investigating the economy of compression in the steam-engine cylinder which yielded results that throw additional light on the subject of compression. These tests were made by Ray L. Bartlett and Robert R. Fisher, senior engineers, for their graduating thesis.

Apparatus

The tests were made on the high-pressure cylinder of a compound Corliss, 10 and 24 by 30-in. engine, designed and built by the H. N. Strait Mfg. Co., of Kansas City, belted to a three-wire, direct-current generator rated at 55 kw. As the low-pressure side was disconnected, the tests can be considered as made on a simple noncondensing Corliss. The engine was designed for 200 lb. steam pressure and ran from 50 to 125 r.p.m. The inlet valves were single ported and the exhaust valves double ported. The governor was of the flyball, center-weight type, and the engine was provided with double eccentrics for both cylinders.

Manner of Conducting Tests

Before performing the tests the clearance was accurately determined by filling the clearance space with water and an investigation made to determine whether or not the valves and piston head were tight. It was found that the clearance, head end, amounted to 6.18 per cent. of the cylinder volume and at the crank end, 7.32 per cent., or an average of 6.75 per cent. Preliminary investigation showed that the piston was tight for the full length of stroke and that there was a small amount of leakage past both the steam and the exhaust valves, that past the exhaust valves being the greater.

The load was maintained by means of a water rheostat. Eleven runs of one hour each were made, with four settings on the exhaust valve to give four compression values, ranging from 21 to 92.4 per cent. of admission pressure. Runs were made at three different cutoffs for each compression. The engine would not carry full load with compression to initial pressure.

The condensate was weighed every half hour and indicator diagrams were taken every 10 min. The load was maintained constant during each run. The initial pressure at the engine was maintained constant at 115 lb. gage. A steam separator in the line just above the engine delivered steam to the engine at an average quality of 0.99.

Theoretical Considerations

Theoretically there are three points in favor of compression:

1. Compression serves as a cushion for the moving

rts and does away with the shock of the entering steam admission.

2. It causes the cylinder to be heated up and thus reces the initial condensation.

3. By filling the clearance space with exhaust steam, he amount of live steam entering the cylinder is reced.

A series of calculations were made to find the theoetical steam consumption of the engine on which the sts were to be made, at four different cutoffs with four fferent compressions at each cutoff. In these calculaons it is assumed that the expansion of steam is accordg to the equilateral hyperbola, for which the equation is $PV = Constant$, and that there is no interchange of heat tween the steam and cylinder walls.

The results of these calculations are shown in the rves, Fig. 1. These show a decreasing steam consumpon with increasing compression up to the point where

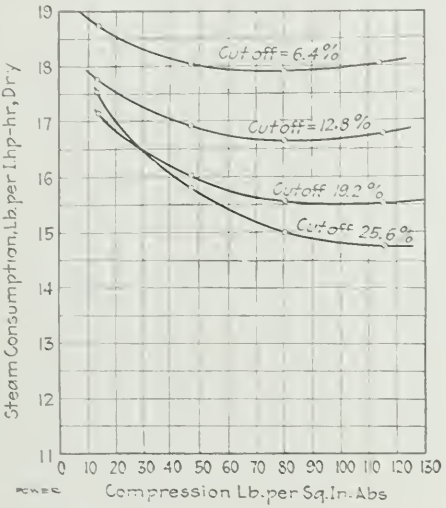


Fig. 1. Theoretical Steam Consumption

he steam is compressed through a greater range than it expanded.

Results of Tests

The results of the tests are shown graphically in Fig. as corrected for steam quality and indicator-spring er-or. The four sample cards in Fig. 3 show the steps by hich compression was increased.

With a load of about 11 kw., the steam consumption Fig. 2) varied within wide limits being abnormally high or both no compression and full compression. With a oad of 28.5 kw. the curve, while following the same gen-ral direction, does not vary in such a pronounced man-er, while the curve for 44 kw. is very much flatter.

The reasons for the gradual flattening of these curves, dicating that the effects of compression become smaller latively as the load increases, may be seen by a con-deration of the following points:

As the clearance volume is partly filled by compression team and thus is partially nullified in effect, the steam onsumption decreases until a point is reached where three other influences overcome the good effects of filling the clearance volume with steam at increased pressure. These are:

1. Condensation of the entrapped steam.

This process of using work from the flywheel to im-

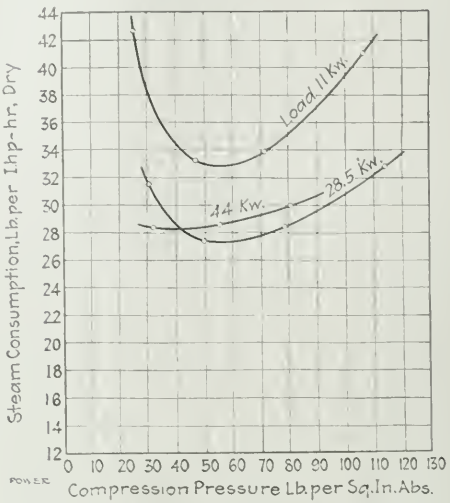


Fig. 2. Actual Steam Consumption

part heat to the cylinder walls is one of low efficiency compared to the process of using the heat from initial condensation.

2. Leakage past the valves which is greater with increased pressure.

3. The compression of steam through a range approximating or greater than that through which it is expanded so that a part of the work done by the piston on the steam may be actually thrown away.

These three factors cause a rising steam consumption from this point because, while almost entirely absent at

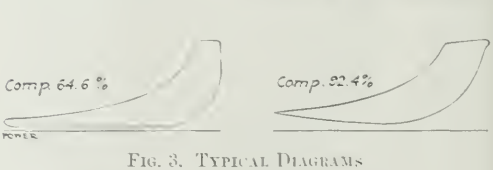


Fig. 3. Typical Diagrams

low compression, they become accentuated at high compression. When compression is carried only high enough so that condensation is moderate and compression is not used in any considerable degree as a means of heating up the cylinder walls, its action is highly beneficial in reducing the clearance volume by filling it with exhaust steam. But Professor Dwelschauvers-Dery has shown that the use of compression as a means of reducing initial condensation results only in a loss of economy.

It may be noted here that the results of the tests made by Professor Carpenter in showing increasing steam consumption as the compression pressure was varied from 42.8 to 87.2 per cent. of the initial pressure, confirm the present results which show increasing steam consumption between these same limits. The tests made by Professor Carpenter are incomplete in not showing the effect on steam consumption of compression lower than 42 per cent.

The curves in Fig. 2 show also that clearance is detrimental to engine economy, for as the load on the engine is increased and the effect of the loss, due to clearance, becomes a smaller percentage of the steam consumption, the engine shows increased economy.

It may be argued that the cause of increasing steam consumption with increasing compression lies in the design of the exhaust valves which, not being designed for high compression, do not release as quickly as they should. In reply to this criticism it may be said that it does not apply to the runs made with compression below normal. In order to see what effect this factor has at high compression the work represented by the area which would have been included had the back-pressure line been horizontal up to the beginning of compression, was calculated from a number of indicator diagrams and credited to the engine with the following results:

Recalculating the steam consumption for the load of 38.5 kw., which is the only load at which the back-pressure line is noticeably abnormal, and crediting the engine with the work represented by the area above indicated, reduced the steam consumption for this compression from 32.85 lb. to 30.04 lb. per i.hp.-hr. But this still leaves the steam consumption 1.58 lb. above that for 62.6 per cent. compression.

It may be further noted that the inability of the exhaust valves to quickly release at very high compression is another point against high compression.

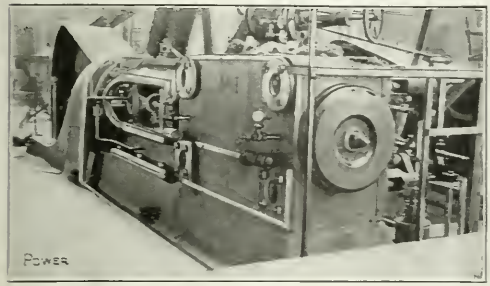


FIG. 4. ENGINE UPON WHICH TEST WAS MADE

CONCLUSIONS

The tests show that for a 10×30-in. noncondensing Corliss with about 7 per cent. clearance and running at 112 r.p.m., compression to about 45 per cent. of the initial absolute pressure gives the highest steam economy. The exact compression, which should be carried by engines of different design running at different piston speeds, cannot be stated unreservedly, but it would seem that some degree of compression approximating 45 per cent. of the absolute initial pressure is economical for the majority of engines.

In estimating the value of these results, weight must be given to the fact that these tests were made on a commercial engine running under ordinary conditions and not on an engine especially designed for laboratory work and tested under abnormal conditions.

While leakage past the valves existed in a moderate degree, particularly past the exhaust valves, this amounted to no more than would be expected in all ordinary engines of standard design. Engineers may feel assured, therefore, that in adjusting their exhaust valves to give sufficient cushion steam to insure smoothest operation they are not sacrificing anything in steam economy but probably are adjusting for a condition that will give approximately the best results.

*

The Wheeler Turbo Air Pump

A centrifugal pump, discharging into an ejector, will remove air and vapors from a condenser and will maintain a high vacuum, provided sufficient water at a high enough head is discharged into the ejector. But the air-entraining capacity of an ejector is limited so that such an air-removing apparatus would be costly and wasteful of power and would be unable to meet overloads due to excessive air leakage. A method of increasing air-handling capacity is to cause the water to discharge intermittently into the ejector nozzle so that it entraps air between successive discharges, as well as entraining it on its surface. A pump constructed on this principle has recently come into use in both this country and abroad.

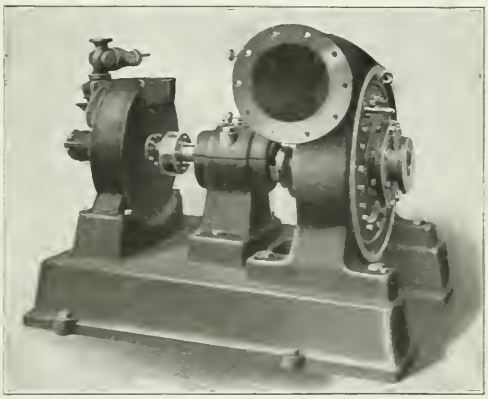


FIG. 1. WHEELER TURBO AIR PUMP

The Wheeler turbo air pump has been developed along somewhat different lines. This pump is based on the designs of the German pump built by the Allgemeine Elektricitats Gesellschaft and is manufactured by the Wheeler Condenser & Engineering Co., Carteret, N. J. An apparent difference in design is the entire absence of the external ejector nozzle.

In general appearance the air pump, Fig. 1, is similar to a centrifugal pump. It is driven at high speed by either a motor or turbine. The pump shown diagrammatically in Fig. 2 consists of a small high-speed impeller with a large number of ports or nozzles on its periphery; secondly, a ring of tapered compression channels, and,

hird, a discharge casing or volute (not shown). Hurling or throwing water enters the eye of the impeller as in an ordinary side-suction centrifugal pump and is impelled at high velocity through the ports in the impeller which rotates in the opposite direction to the impeller of a cen-

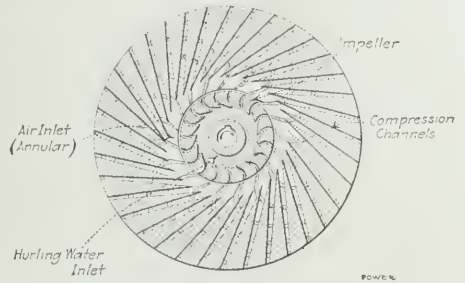


Fig. 2. Showing Principle of Air Removal

rifugal pump. Air is admitted around the entire periphery of the impeller and is drawn into the entrance of the tapered compressor channels by the aspirating effect of the rapidly discharged water. As the slugs of water move outward they become elongated, owing to the tapering of the channels, the space between slugs decreases and the air entrapped is compressed. The mixture of air and water is discharged from the tapered channels into a volute casing, somewhat similar to that of a centrifugal pump, and is finally discharged through a suitable outlet nozzle.

These pumps are used for both jet and surface condensers. For the latter service, the turbo air pump is frequently combined within a common casing with the condensate pump. In Fig. 3 is illustrated a combined pump of this type. Air and condensate are withdrawn from the surface condenser through a common pipe, flowing to a common suction nozzle on the pump. Just within the

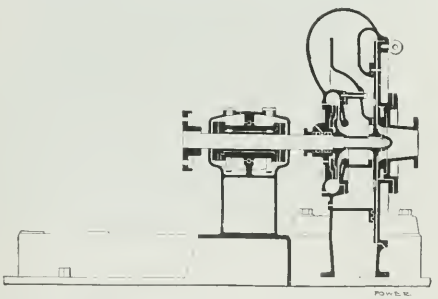


Fig. 3. Cross-Section through Turbo Air Pump

nozzle is a partition which separates the air and water, the latter flowing by gravity to the eye of the condensate impeller, which is of the ordinary centrifugal pump design, while the air and gases flow over the partition wall, direct to the annular air inlet surrounding the hurling water impeller of the air pump. Within the single casting two volutes are formed, one for condensate, the other for hurling water and air, so that as far as operation is concerned, the two pumps are entirely independent. However, a distinct saving results, because the amount of piping between the condenser and the pump is reduced and simplified, the space ordinarily required by the two pumps for air and condensate is greatly reduced, and both pumps are driven on a single shaft by a common turbine, thus saving power.

Pumps of this type will maintain a vacuum of 98-99 per cent. of theoretical, that is within a very small fraction of an inch of the vacuum corresponding to the temperature of the hurling or throwing water. This is not only true for low temperatures of water from 32 to 60 deg., but also for hurling water at temperatures of 70, 80, 90 deg., and higher, as encountered in the summer

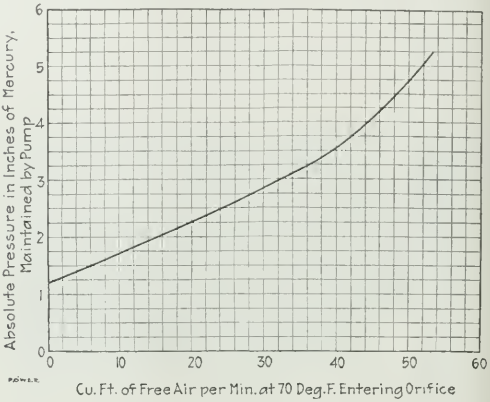


Fig. 4. Relation of Air Capacity to Absolute Pressure Maintained

months and in cooling-tower work. The curve of Fig. 4 shows the air capacity in cubic feet of free air at 70 deg. F., plotted against the inches of absolute pressure maintained by a recent pump. The hurling or throwing-water temperature was 78 deg. F., which corresponds to a vacuum pressure of 0.96 in. of mercury, which is to be compared with the maximum vacuum obtained by the pump of 1.1 in. absolute pressure.

An important characteristic of this pump as demon-

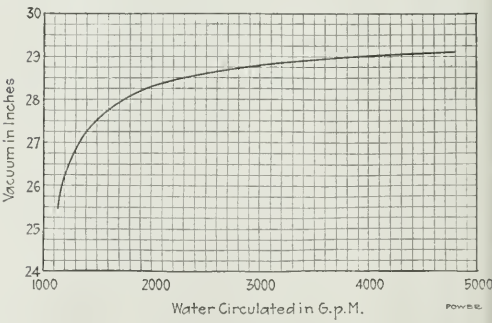


Fig. 5. Relation of Vacuum Maintained to Quantity of Condensing Water

strated by this curve is the large free air-handling capacity and its ability to withstand overloads. This follows from the fact that there is a positive aspirating effect at the entrance of the numerous tapered compression channels, into which air must be drawn so long as the im-

peller rotates and discharges water. Accordingly it is found that an increase in load or the cubic feet of free air handled, does not cause failure of the pump, but simply a fall in vacuum not unsimilar to the characteristic of a displacement-type pump. The operating importance of this point is that if the air leakage on a condenser be increased at any time, due, for instance, to failure of the turbine seals, the pump will not refuse to handle the added load with a resulting break in the vacuum, but will maintain a moderate vacuum until the air-leakage trouble has been corrected. A too common experience with ejector air pumps is a failure of the vacuum because of a transient increase in air leakage.

In Fig. 5 is shown the relation between vacuum maintained by a surface condenser equipped with a turbo air pump of this type and the amount of condenser circulating water in gallons per minute. The vacuum maintained and outlet circulating-water temperatures are given for a number of points on the chart; for instance, with 4400 gal. of water per min., the vacuum maintained was 29.13 in., with the outlet cooling water at 70 deg., which corresponds to a maximum theoretical vacuum of 29.30 in.; that is, 0.17 in. higher than the actual vacuum maintained. Similarly with 1720 gal. of water per min. the vacuum maintained was 28 in. and the outlet cooling-water temperature 98.6 deg., corresponding to a maximum theoretical vacuum of 28.11 in.

Besides indicating the excellent performance of turbo air pumps of this design in connection with surface condensers, this chart is of additional interest in that it shows the increase in cooling water necessary to obtain very high vacuum. The temperature of the inlet cooling water was about 50 deg. To maintain a 29.1-in. vacuum, it was necessary to use almost four times as much water for a 26-in. vacuum and 2½ times as much water than for a 28-in. vacuum.

Power for Pumping Derived from Refuse*

Those who have not followed the more recent developments in the disposal of city refuse, will be somewhat surprised to learn that in a number of places part, if not all, of the steam used in driving steam pumps at water-works pumping stations is derived from burning waste material. As a result of the development in the incinerator method of disposing of mixed refuse in England and in continental cities, several plants have been installed in this country and, in all probability, the older and less sanitary methods hitherto in vogue will gradually give way to this more modern method, particularly as our cities increase in size.

Having produced the effect of destroying refuse in a sanitary and inoffensive manner, the question of how best to utilize this heat is answered by combining a steam boiler with the furnace and producing steam at any desired pressure. Steam so produced is available for running engines to produce electricity but, as a rule, the amount which could be produced is but a small proportion of the total amount consumed by the community; also, the operation of the destructor does not lend itself to the requirements of peak loads which are incident to all lighting and power stations. A pumping load, however, is ideal for a destructor because of its uniformity and constancy, and it is in this direction that a municipality has its greatest opportunity for conserving this energy.

It would hardly be expected that the exact amount of steam available from the destructor would coincide with the exact amount of steam required at the pumping station, but the almost invariable condition is that the destructor steam is somewhat less than required by the pumps. Therefore, the difference is made up by auxiliary boilers.

The steam may be passed direct from the destructor to the steam range of the pumping station or converted into electricity and used to drive motor-driven pumps. Instances where steam from a destructor is used directly for driving pumps are found at Montgomery, Ala.; Westmount, near Montreal, Ontario, Canada, and Savannah, Ga., while instances where the power is first converted into electricity and the current used to drive motor-driven pumps to furnish the water are found at Milwaukee, Wis., and Savannah, Ga.

*From a paper by E. H. Foster before the American Water-Works Association, at Minneapolis, Minn., June 23-28, 1913.

Peat Powder as Fuel

The announcement that Hjalmar von Porat, a Swedish engineer, had perfected a process for utilizing peat powder as fuel for locomotives has awakened interest in the possibility of developing the extensive peat bogs of Sweden for this purpose.

The powder is manufactured by the Ekelund process. It does not appear that this process has made much headway as yet, but it is now predicted that in connection with the discovery of Mr. von Porat, the use of peat powder will in time become extensive.

In the von Porat system the peat powder is fed by an automatic device into the furnace of the locomotive, which is specially arranged to consume it. According to Mr. von Porat, the results obtained with peat powder may be summed up as follows:

> Substantially the same results can be had from 1½ tons of peat powder that 1 ton of coal will produce. Peat powder may be burned with an admixture of about 5 per cent. of coal. As to firing with peat powder, the work is almost nothing in comparison with firing with coal, because the powder is forced into the furnace by automatic process. No change had to be made in the boiler and none in the fire box, except installing the special apparatus. There is no difficulty in bringing the powder from the tender to the fire box, as it passes through a conveyance pipe. Another advantage in using peat powder is that no cold air can get into the fire box and neither smoke nor sparks escape from the smokestack.

As a result of von Porat's invention, it is reported that a number of the Swedish railways are preparing to use peat powder instead of coal.

It is reported that a compressor which has been running at the power house of the Nevada Consolidated Copper Co., 24 hr. per day for the last five years is compressing 16,000,000 cu.ft. of free air per gallon of lubricating oil and without bad effects on the machine. This is an excellent record and is worth looking into a little. A compressor with an intake cylinder 24 in. in diameter, which is quite a common size, and a piston speed of 400 ft. per min., will compress, say, 1200 cu.ft. of free air per minute, or 1,728,000 cu.ft. per 24 hr. Then the oil used per day, at the rate of consumption given above, would be only 0.108 gal, or less than a pint for the 24 hr.—"Compressed Air Magazine."

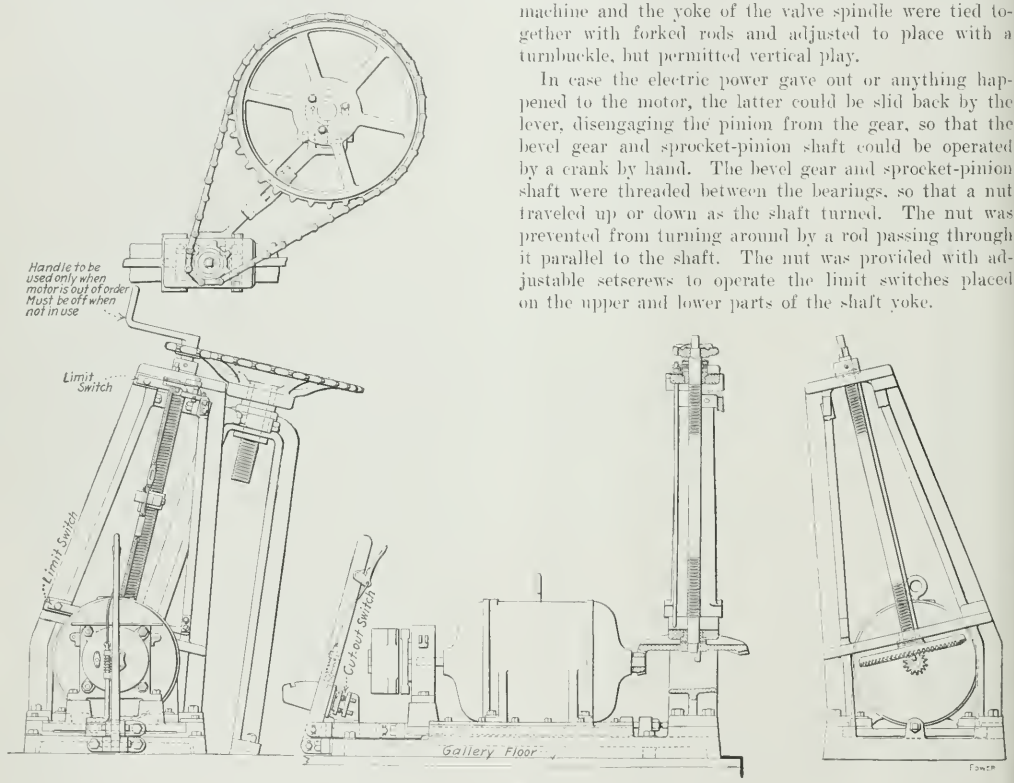
ELECTRICAL DEPARTMENT

Motor Drive for a 28-in. Valve

By James R. Allen

Some time ago the writer designed a motor drive for a 28-in. exhaust valve which proved very satisfactory. The turbine was situated on the gallery floor of the power house and exhausted through a 28-in. crane valve to a jet condenser which rested on the basement floor and stood up in the opening between the galleries. The exhaust-valve stem came up just outside the gallery floor and tipped one hole to clear the side of the condenser so that to operate the valve a man had to lean over the gallery railing and turn the valve 57½ times to open or close it, which took too much time and labor.

Because of the elevation of the gallery floor and the variation of the center line of the 28-in. exhaust valve, when the condenser was filled with water a chain and sprocket drive, which permitted flexibility, was used. The device was set opposite the valve close to the edge of the gallery floor.


Handle to be used only when motor is out of order Must be off when not in use
Limit Switch
Limit Switch
Cut-out Switch
Gallery Floor

Plan and Elevation of Motor Drive for Valve

An old 2-hp., direct-current motor was found and set on the base, sliding in ways on the bedplate. An electric brake was also connected to the motor shaft and fastened to the base so that when the current was thrown off the motor it would stop instantly.

The yoke casting, carrying the bevel gear and sprocket-pinion shaft, was fastened to the bedplate and tipped to suit the angle of the valve. The yoke casting of the machine and the yoke of the valve spindle were tied together with forked rods and adjusted to place with a turnbuckle, but permitted vertical play.

In case the electric power gave out or anything happened to the motor, the latter could be slid back by the lever, disengaging the pinion from the gear, so that the bevel gear and sprocket-pinion shaft could be operated by a crank by hand. The bevel gear and sprocket-pinion shaft were threaded between the bearings, so that a nut traveled up or down as the shaft turned. The nut was prevented from turning around by a rod passing through it parallel to the shaft. The nut was provided with adjustable setscrews to operate the limit switches placed on the upper and lower parts of the shaft yoke.

The limit switches were set so that the current would be shut off just before the valve seated itself or was fully opened. The switches were provided with carbons to draw the arc so as not to burn them. The upper and lower hinged parts of the limit switches were connected by rods and a tension spring so that they were always held on their contact bars unless lifted by the traveling nut and the contact broken, thus stopping the motor.

A cutout switch connected before the motor with its terminals fastened to the lever sector and a contact bar on the lever, prevented the motor destroying itself if it was disengaged from the bevel gear and the current was

identally thrown on. A sprocket wheel was fitted to te nut on the valve spindle in place of the handwheel d connected with a sprocket chain to the sprocket nion.

The bevel pinion had 16 teeth, the bevel gear 80 teeth d the traveling nut was threaded 11 threads per inch th approximately 30-in. travel. The sprocket pinion d seven teeth, and the sprocket gear 34 teeth, so that e valve-spindle sprocket gear made 74 r.p.m. with the otor running 1800 r.p.m.

A forward and reverse switch was placed near the turne throttle so that the engineer could open or close e valve at pleasure.

The device did not cost as much to make as to purase a regular motor-operated valve. It is practically oolproof and has not been out of order since it was ade.

Some Electrical Fallacies

By Arthur H. Allen

In all vocations there are certain beliefs more or less rmly rooted in the popular imagination, but actually ased upon erroneous ideas, and the electrical industry no exception; indeed, in earlier days it bristled with llacies, but many of these have been exploded. Neverneless, there is still a fair number which persist in spite f the advance of technical education and of repeated isproof.

The writer recently heard it stated that a motor could e built which would run faster if the load on the shaft ere increased. A similar statement, many years ago, nduced him to try experiments on various motors, changng the excitation, the position of the brushes, and so n, with a view to putting the statement to test, as he oubted the possibility of such an achievement. The reults were entirely negative, and consideration shows hat this must necessarily be so. In the case of a direct-urrent motor, the current through the armature (at onstant voltage) cannot possibly increase unless the ounter electromotive force is first reduced, and this cannot take place unless either the speed is lowered or the ield weakened. But the armature cannot carry an inreased load unless the current through it is increased, or the field strengthened. With constant voltage, the atter alternative is inadmissible; therefore the speed nust fall when the load is increased. A larger current hen flows, and this may weaken the field in two ways: by armature reaction, or by a series winding in opposiion to the shunt winding, or both. In order to restore he original speed, the field must be weaker, while on the ther hand, in order to carry the increased torque, the roduct of armature current and field strength must be reater than before Armature reaction alone is not suffiient to bring about the necessary weakening of the field, o that a shunt motor always falls in speed as its load ncreases. By means of a differential series winding, howver, it is possible to weaken the field when the current ncreases, and thus the speed can be maintained very nearly constant.

The action is similar to that of a mechanical governor on a steam engine, which can be so designed and adusted that a very small fall in speed results in the admission of an increased quantity of steam at each stroke to carry an increased load; but it is well known to engineers that if the governor is made too sensitive the engine will hunt—the correction applied through the action of the governor may be too great, and the speed of the engine will become irregular. Hence it is necessary to allow a drop in speed of at least 2 or 3 per cent. between no load and full load, to insure stable running, and precisely the same thing applies to the direct-current motor. If the compensation for increased load provided by the differential series winding is too great, the speed will become unstable. Hence, it is necessary to allow a small but definite drop in speed with increasing load. With the aid of relays, the problem can be solved, but that is another question.

Another fallacy which is still often met with is that of "bedding" in the winding of a solenoid. It is stated that some economy in winding space can be derived from the bedding of round wires in the successive layers, as shown in Fig. 1, but this is a wholly erroneous view. The successive layers are respectively right- and left-hand spirals, and if one considers the analogous case of a left-handed bolt screwed into a right-hand nut, it will at once be seen that the respective threads cross one another, so that the bolt cannot even enter the nut unless the outside diameter of the former is equal to or less than the inside diameter of the latter. They will not go together at all. The threads of a right-hand bolt and a right-hand nut, however, if of the same pitch, "bed" together perfectly. Now, whether the cross-section of the former on which a

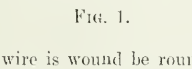


Fig. 1.

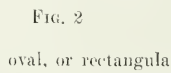


Fig. 2

coil of wire is wound be round, oval, or rectangular, the fact remains that the windings are alternately right- and left-hand spirals, and even if they bed on the corners of the former, the turns must cross one another at two points in each convolution: at those points the layers are in the position shown in Fig. 2, and there is no bedding.

Again, take the "extra current," so called, which flows at the moment of interrupting an inductive circuit, such as that of a field-magnet coil. There are many who believe that at that moment there is a rush of current, of greater amperage than the current which was flowing before the interruption commenced. The name certainly suggests this idea, which, however, is totally wrong. Of course, the current persists for a short interval, producing a spark; but the act of interrupting the circuit is simply that of increasing the resistance in the circuit more or less abruptly, and the current actually diminishes from the first moment. What really happens is that the fall in the value of the current, which is necessarily accompanied by the collapse of a number of lines of force (using the ordinary convention), and, therefore, by the intersection of the convolutions of the winding by lines of force, results in the production of an electromotive force acting in the same direction as the original electromotive force, and thus tends to maintain the current flowing, or, in other words, which, perhaps, more correctly describe the phenomenon, it opposses the change in the conditions, in accordance with the law of Lenz. If the circuit is very suddenly interrupted, this induced electromotive force

may reach an extraordinarily high value, and has often been known to cause the puncture of the insulation of a solenoid; it is, indeed, an "extra voltage" in the sense of an increased voltage, but *the current diminishes all the time.*

Take now the question of overleaping of current when switching on a tungsten lamp. The resistance of the filament is low at first, the filament being cold. A given voltage, therefore, produces a current far in excess of the normal current, causing the filament to be heated very rapidly. It is easy to fancy that the heating has a sort of inertia, which causes it to overleap the proper limit, so that the filament attains a higher temperature than the normal ultimate value, but this is an erroneous view. The current is always equal to the ratio of the effective voltage in the circuit to the resistance in the circuit at the moment, and as the temperature of the filament (and, therefore, its resistance) rises, so the current necessarily falls, until the point is reached where the current flowing just suffices to maintain the temperature that the filament has attained. A good analogy is a tank fitted with an automatic ball-valve connected with a water supply. If the water is turned on when the tank is empty, it rushes in at first at full bore; then as the tank gradually fills, the ball rises and gradually closes the valve, till when the tank is nearly full the water comes in at a mere trickle. When the tank is quite full the flow of water has been completely stopped. The tank is never filled above that limit. There is only one way in which overfilling could be produced—namely, by the presence of inertia of some kind in some part of the apparatus.

In the case of the tungsten lamp, the electromagnetic inertia known as inductance may supply that condition. Another factor by which the effect of inertia may be produced is that of capacity for heat: the parts of the filament close to the terminal electrodes, and those which are in contact with the supporting hooks, do not heat up so rapidly as the intermediate parts, and thus their resistance does not increase at the same rate. The result is that the resistance is less, and, therefore, the current is greater, at the moment when the temperature of the filament passes through the normal limit, than they will ultimately become, and this would cause a momentary excess of heat and brilliancy. That such overleaping does take place in many cases cannot be denied; but it is not due to the upward rush of the temperature, but to causes such as those above mentioned. No circuit is completely noninductive, and no tungsten lamp of ordinary dimensions is free from the wire hooks, etc., which might account for the phenomenon.

Lightning Protection*

There are two classes of lightning strokes, direct and indirect. The direct stroke is, as the name implies, something in the direct path of lightning to the ground. This kind of a stroke is so powerful as to render all present forms of lightning protection useless. A power wire exposed to this severe condition is most likely to be exposed to a power arc which follows lightning to the ground and the arc often burns the line conductor in two. The means of support for the power wire sometimes aid or add a destructive element to the whims of lightning. Wooden pole lines are often interrupted because of a shattered pole, and in few instances does lightning strike the wires midway between supports. Again, more trouble has been evident on wooden-pole lines than upon tower lines. This is because of the greater resistance to the flow of lightning offered by the wooden-pole line, whereas the steel towers are of ground potential.

The indirect stroke of lightning is detrimental to good service because of the effect produced. This induced stroke which affects the line in the immediate vicinity of the direct stroke, builds up a potential nearest the path of the lightning often of such magnitude as to strike out and attract the lightning to the conductor.

It would seem evident that bringing the potential of the earth to an elevation higher than the power wires would be the best means of protection. The most usual manner of obtaining this protection, in a degree, is to place a single wire at the extreme top of the structure and have this parallel the main power conductors. This conductor is grounded at intervals, and is known as the ground wire. When lightning is being conducted to earth along this wire, an induced potential is often produced on the main-line conductors, occasionally so high as to cause a "spill-over" of the insulators. To prevent this dangerous rise of potential on the line, it is best to ground the wire about every 375 ft.

The multigap arrester, at the time it was devised, afforded what was considered the best means of protection. It had the disadvantage of having parts affected by the current which, in turn, affected the sensitiveness of the arrester. That portion affected was the gnarled edges which burned off and increased the gap, thereby making it necessary to attain a greater potential before a path to the ground is obtained. This arrester is in use on voltages up to 33,000 and 44,000 volts.

An arrester known as the compression type has been produced for voltages up to 10,000. This is a form of multigap arrester embodying similar principles with distinct feature. It requires little space, and is mounted on the transformer pole, one arrester placed in each phase. Upon a short-circuit it attains a temperature such as to cause a cap to be forced off, and in this way opens the circuit.

The open-air horn-gap arrester is a combination of a horn gap and a choke coil; the action is as follows: The surge passes along the line to a choke coil, and it is immediately retarded until a potential great enough to jump the gap is attained, at which time the choke coil acts as a magnetic blowout, and the arc is carried up the horns and is dissipated. It is recommended to place a fused horn gap in series with the line to prevent heavy rushes of current. The fuse prevents its being a self-sustained arrester.

The electrolytic arrester is still the arrester upon which the greatest burden of protection lies. This has remained of the same design and has proved to be the most satisfactory means of protection from lightning on systems of high voltage. It dissipates surges from the line, and removes abnormal conditions.

In any case, the arrester used depends primarily upon the ground connections. One of the best methods of obtaining a ground in a station is to drive galvanized-iron pipes into the earth at different places, all the pipes to be well salted just below the surface of the earth and electrically tied together.

*Excerpt from report of the Electrical Transmission Committee of the Ohio Electric Light Association.

GAS POWER DEPARTMENT

Effect of Variable Load on Gas Producers

By Reginald Trautschold

In the past manufacturers of suction-gas producers often made claims for economic operation that were not realized in ordinary practice, although they may have been exceeded in tests made at the factories or in certain installations where all conditions were peculiarly favorable. Much progress has now been made in the design of gas producers and the conservative manufacturer no longer guarantees exaggerated economies, such as a horsepower for ¾ or 1 lb. of fuel, it being possible to get only a certain number of B.t.u. from a fuel and it is in but rare exceptions that more than one-third of the available heat can be converted into useful energy. At present, the rating of gas producers is much more liberal than formerly and few manufacturers now care to guarantee a horsepower on less than about 1¼ lb. of anthracite coal, although some installations are doing better than this.

The manufacturer is now confronted by another trying proposition, namely, to guarantee the effect of variable load on the economy of the gas producer. Possibly this is another stumbling block, for guarantees such as a fuel consumption of 1¼ lb. per b.hp.-hr. from three-quarters to full load, and 1½ lb. per b.hp.-hr. with half load, are made by some of the most conservative manufacturers. Owners should know that a gas engine is not equally efficient under all degrees of load and, therefore, should not expect to be protected by any such guarantee on the part of the producer manufacturer.

Variable load has little effect upon the economy of a correctly designed gas producer; which, instead, depends directly upon the efficiency of the gas engine, and any guarantee that the fuel consumption of a gas producer will not exceed a certain amount under a given load must be extremely conservative to be realized in every installation. The only reliable guarantee that can be made is that the fuel consumption of the producer will not vary more than 2 per cent., for any load, from the efficiency of the power unit operating under the same load. The efficiency of a gas engine varies under different degrees of load and so many conditions enter into the problem that it may be impossible for the gas producer to be operated efficiently because of inefficient operation of the gas engine. It is possible, of course, to guarantee a certain rate of gas generation in a suction-gas producer from a particular grade of coal, but such rating would not be convenient nor satisfy the operator. He desires to know how much fuel is required to generate certain power at the engine.

A suction-gas producer consists simply of a closed chamber in which a solid fuel is converted into a combustible gas. This conversion is only possible through the admittance to the producer of a certain quantity of air for combustion and the reducing medium that brings about the chemical reduction in the products of combustion. The supply of these direct and negative reaction mediums depends upon the suction of the engine, and, hence is directly dependent upon the engine requirements for fuel. This withdrawal of gas is equal to the consumption of fuel by the engine and it is, therefore, impossible to have other than the same economy in both the producer and the engine, with possibly the exception of the 2 per cent. referred to in the suggested guarantee. This 2 per cent. may occasionally occur, due to the fact that a gas producer is very similar to a thermos bottle, storing up heat, so that the fire bed is maintained at a practically constant temperature, irrespective of the rate of gasification in the producer. A small portion of any producer gas consists of hydrocarbons that are driven off from the fuel; therefore, a slight excess of such hydrocarbons might be present in the delivered gas at a time of supplying green fuel, thus increasing the richness of the gas during a short period. A varying richness of gas reduces the efficiency of the gas engine—a reduction that can rightfully be charged against the gas producer.

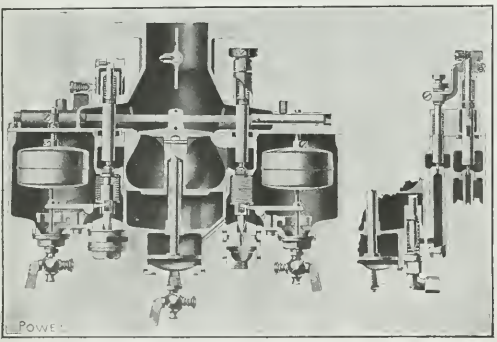
Sudden variations of load are conducive to reduction of engine efficiency, naturally, and correspondingly to poorer economy of fuel consumption by the producer, for no engine governor has yet been devised that can instantly take care of a considerable drop or increase in load. The period of reduced efficiency of the engine is ordinarily of sufficient duration for the gasification in a gas producer to accommodate itself to the demands for fuel, and several of the most successful gas producers depend for their economic operation on this fact—a dependence that actual operating results indicate as permissible. One eminently successful producer, however, is provided with an additional precaution against unnecessary gasification through a bypass connection leading from the gas holder back to the scrubber. In this producer, excess of gas, at a time of sudden drop in the engine load, returns to the scrubber and thus the vacuum throughout the gas-producer system is reduced and gasification is retarded until the engine load increases and the demands for fuel are correspondingly greater.

Standby periods represent certain losses in efficiency of all generators, but here the gas producer is far more economical than steam boilers. Gasification practically stops on the breaking of the vacuum in the system—on a shutdown. That is, on the cessation of operation, the purge or stack pipes of gas producers are opened to the atmosphere and the complete combustion of fuel is necessarily very slow. The condition existing in the producer is a relatively deep mass of incandescent fuel with very little oxygen supply for combustion. The ordinary air supply for the fuel charge is practically cut off and little air enters the producer chamber, except through leakage or down the open stacks. Combustion being thus minimized and there being little circulation, the producer stores up its heat during inoperative hours so that when operations are again resumed by the admittance of air,

the fuel bed is easily revived. The dormant condition of the producer can be maintained for a considerable period, ample to care for any ordinary standby condition. Even should such a period extend over a week or two, it is uneconomical to pull the fires. During a standby period of such length it is customary to admit no air during the first 12 hr. or so and then only sufficient air to revive the fire somewhat, when it should be again cut off and the producer allowed to remain in the dormant state for a day or two before again reviving the fuel bed. Charging the producer or supplying it with fuel during lay-over periods is also inadvisable, for such new fuel tends to bake or fuse together, increasing the difficulty in starting up the producer. Should the producer-fuel charge, at time of shutdown, be insufficient to last over the standby period it is more economical to pull the fires than to attempt to maintain them by the addition of fuel. Starting up a producer after a shutdown over night or after a lay-over period necessitates some waste of fuel during the time required to revive the charge by "blowing"—ordinarily not more than 15 or 20 min.—but this loss is practically the only direct loss of the gas producer.

New Combination Carburetor

Charles Rayfield, inventor of the well known Rayfield carburetor used on automobiles, has been experimenting for some time on kerosene carburetion, and has brought out a combination carburetor employing kerosene, gasoline and water, which is intended for use on traction, stationary and marine engines.



Section through Rayfield Carburetor

The operation of this carburetor is automatic. It is so designed that a proper mixture is supplied under all speeds and under all loads, using kerosene, distillate or other low-grade fuel. The fuel and air openings are operated by a floating double-poppet valve, which is lifted by the suction of the motor in proportion to the speed.

Two float chambers are used, making it possible to start at any time on gasoline. The shifting of a small lever by the operator shuts off the gasoline and opens the kerosene port, instantly changing the mixture from one fuel to the other.

Separate adjustments are necessary for each fuel and this requirement is met by the installation of separate needles, thus making it unnecessary to change the adjustment when switching suddenly from one fuel to the other. One air inlet answers when using either fuel. Heat to assist in vaporizing the fuel is supplied by a hot-air tube from the exhaust manifold.

This carburetor is not intended for use on automobile motors, but it is understood that Mr. Rayfield is now experimenting along this line. The carburetor is made by the Findeisen & Kropf Manufacturing Co., Chicago.

Splash Lubrication

One noticeable feature in the operation of gas engines is that the vertical engine running with the splash system consumes more oil than the hand-oiled horizontal engine of the same horsepower. In the case of the hand-oiled engine, if the cups are feeding too fast they can easily be adjusted, but in the case of the splash system one must keep the oil to a certain level in the crank case and let the connecting-rod bolts throw all the oil that will cling to them. It is common to find a 100-hp. splash-feed engine consuming 4 to 8 gal. of oil in 24 hr.; while 1 gal. will easily lubricate the hand-oiled engine.

I had a case some time ago of a vertical engine that consumed 5 gal. in 11 hr. A representative of a well known oil firm came along and said if I would use his oil it would only take 1 gal. per day as the oil I was using was no good. This new oil cost three times as much as the old. However, after considerable controversy, our firm decided to order two barrels. The crank case was cleaned out and 35 gal. of the new oil was put in and in order to keep the proper level while the engine was running it was necessary to use just as much of the high-priced oil as of the cheaper oil. I decided to lower the oil in the case and stop the engine throwing so much up in the cylinder. Therefore, I lowered the level so that the bolts passing through the end of the connecting-rod and through the crankpin bearings did not touch the oil.

I took out a bolt at the back of each connecting-rod and drilled and tapped a hole in the lower end for a ½-in. stud; then bent the stud to a right angle at the bottom after having flattened the end to a spoon shape. I screwed the stud into the end of the bolt and secured it with a locknut, then replaced the bolt. The stud dipped in the oil to a depth of 1¼ in. When the engine was started, I took care to see that the cylinders were not running hot and after a 5-hr. run shut down and found the cylinder walls well oiled. This cut the oil consumption down to 1 gal. per day. The 7x18-in. bearing, however, was not getting enough oil, so something had to be done to use the oil over again from the case. I, therefore, procured a small plunger pump which had been used to circulate the jacket water on an automobile; it was 1 in. diameter by 1¾ in. stroke. This I attached to the side of the crank case and drove it by a ⅝-in. connecting-rod from the exhaust camshaft. The pump discharged into a 2-gal. tank situated on the top of the crank case between the two cylinders from which the oil was piped to run through two large (quart) sight-feed oil cups, one on each outside main bearing; also a pipe led to the center bearing in the crank case. Thus the oil ran in a steady stream all the time the engine was in motion. This method supplied the bearings with about 10 gal. of oil an hour, whereas before they only received 1 gal. in 10 hr.

This not only reduced the wear on the bearings, but cut down the oil bill $300 in a year.

Stratford, Ont., Can. Harry Westwood.

HEATING AND VENTILATION

High-Pressure Steam Heating vs. Hot-Water By-Product Plant

By Ira N. Evans

In the issue of Power, June 3, 1913, is a reprint of a paper by F. W. Ballard entitled, "District Steam Heating with High-Pressure Steam."

In the paper above referred to hot water is not considered, but the data of the problem will be used as a basis to determine the financial possibilities of a vacuum hot-water heating system, where turbines could be operated under partial vacuum and the latent heat of the steam utilized in its passage from the engine to the condenser.

With the long distances and consequent expense of mains it is a close proposition from a financial standpoint for any system, and the use of exhaust steam directly in the mains would be out of the question financially. From the comparison as stated with 40 lb. of steam per kw.-hr. for heating and 15 lb. per kw.-hr. for full vacuum, it would seem impossible for any byproduct plant to be successful even for short distances.

In an article in Power, Nov. 26, 1912, on the "Cost of Exhaust-Steam Heating," methods are discussed showing that by the use of hot water under forced circulation for heating, the steam rate for power may be reduced by lowering the temperatures at which the exhaust steam is utilized. At the same time the radiation is operated in extreme weather at the same temperatures as vacuum steam. Under the conditions named the steam rate of the high-vacuum turbine will not be increased to so great an extent and a broader field is opened for byproduct district-heating plants where they would not pay at present.

The total steam for 1000-hr. operation for the proper percentages of time for each outside temperature was given in the article as 59,782,363 lb., or an average of 59,782 lb. per hr. With a maximum rate for heating at —15 deg. outside temperature of 113,832 lb. per hr., the average quantity of steam would be 52.52 per cent. of the maximum. The total kilowatt-hours, including 200,000 for pumping, was 2,090,928, which would give an average rate of

$$\frac{59,782,363}{2,090,928} = 28.6 \text{ } lb. \text{ } per \text{ } kw.\text{-}hr.$$

for heating and power. The steam rate at 28 in. of vacuum was 20 lb. per kw.-hr., on a 500-kw. unit, and with the allowance for the difference in feed requirements at 28 in. of vacuum, or 100 deg. and atmosphere or 212 deg., the rate increased to 22.24 lb. per kw.-hr. from and at 212 deg. The average increase in steam consumption if the 15 lb. in Mr. Ballard's paper included the auxiliaries would be

$$\frac{28.6}{22.25} \times 15 = 19.2$$

or, say, 20 lb. per kw.-hr. for the average rate for heating. The 15 lb. per kw.-hr. is low, but the relation cited in the author's article having been proved out in actual practice, should hold for any other like condition.

An increase in the steam rate from 15 to 20 lb. or 33 per cent., as against 15 lb. and 40 lb. per kw.-hr. changes the complexion of the problem. In Mr. Ballard's paper the full load requires a 15-lb. drop in pressure for the low-pressure system and 68-lb. drop in the high-pressure system. This condition will occur about 2 per cent. of the time, although it has to be provided for in boiler capacity. If the loss in pressure varied as the square of the weight of steam the pressure drop under average conditions with 60 per cent. load factor would reduce to

$$0.60 \times 0.60 = 0.36 = 36 \text{ } per \text{ } cent.$$

Then the average drop on the low-pressure system would be

$$0.36 \times 15 = 5.4 \text{ } lb.$$

and the average drop on the high-pressure system

$$0.36 \times 68 = 24.48 \text{ } lb.$$

Even with 5.4 lb. back pressure it would be difficult to obtain a rate of 40 lb. per kw.-hr. and vacuum on the end of the line would increase the steam volume, requiring enlarged mains and increased expense of installation.

For loss in the value of the exhaust steam for heating, due to its passage through the engine, Mr. Ballard deducts 20 per cent. If turbines are used the exhaust steam should be slightly superheated or at least dry for the same reason that dry or slightly superheated steam is obtained at the end of the heating line. The reciprocating engine may or may not give dry steam, but if cylinder condensation is reduced to a minimum and superheated steam is used, as would of necessity be required for a rate as low as 15 lb., the exhaust steam would be nearly dry at the engine, and there would be no occasion for deducting so large a quantity as 20 per cent.

In comparing a byproduct plant with a straight heating plant the boiler power under average conditions will be 50 to 60 per cent. of that required under maximum conditions. The main saving in a byproduct plant is in the investment in buildings, boilers and equipment required for the maximum load over the average load. The spare boilers for both power and heating can be reduced and made to serve two purposes.

This is one of the main objections to the use of hot-water boilers for district-heating hot-water plants. The extra labor and the fact that the heating plant is discontinued in summer while current is required the year round are two additional arguments in favor of a byproduct plant. With regard to the statement that the loads on the heating and power do not come at the same time, this is largely a matter of business management in obtaining a proper power load to balance the heating. This is one of the prime requisites for a successful byproduct district-heating plant.

With the hot-water plant already referred to in this discussion, practically the same power load in kilowatts would be carried throughout the heating season. The heating requirements are met by simply varying the vac-

mum and steam temperatures with nearly the same power load and increasing and decreasing the steam rate. The consumption would be 30 lb. or more in zero weather and 16 or 17 lb. at 26 in. of vacuum and 55 to 65 deg. outside temperature. This has all been demonstrated in actual practice and all that is necessary is a constant power load sufficient to balance the heating. All surplus or peak would be carried on a separate machine under full vacuum.

The hot-water layout provides a single main in each street with the same capacity to the points indicated in Mr. Ballard's paper. This requires an 18-in. supply main to Euclid Ave. through Wilbur Ave. and One Hundred and Fifth St., a 12-in. return main through One Hundred and Seventh St. to Fairmount Road and Cedar Ave., and a 14-in. O.D. main along Euclid, Carnegie and Cedar. This line and the 12-in. main from One Hundred and Seventh St. join into an 18-in. return main leading back to the plant. The expensive reducing valves are not required on this layout, and any live steam required will be utilized under boiler pressure and temperature in a separate live-steam heater with gravity return to the boilers. The exhaust steam would be utilized in a separate heater or condenser and all condensation would be saved.

A 25-deg. drop and 75,000,000 B.t.u. per hr. as a maximum heating load would require 50,000 lb. of water to be circulated per minute; 30,000 lb. through the 12-in. main and 20,000 lb. through the 14-in. O.D. main. There are 7000 ft. of 18-in. main, 2700 ft. of 12-in. main and 8000 ft. of 14-in. O.D. main, making 17,700 ft. of main as compared to 8200 ft. on the steam system. This arrangement will require a 225-ft. head on the pump and house connections will be shunted off the main with sufficient distance between the terminals to produce circulation. The power to drive the pumps will be

$$225 \times 50{,}000 = 11{,}250{,}000 \textit{ ft.-lb. per min.}$$

or 341 theoretical horsepower. At 70 per cent. efficiency 487 hp., or 365 kw., will be required to circulate the water. It has been demonstrated in former articles that nothing is lost in the pumping. The heat units developing power are all returned in friction and the heat in the exhaust steam is utilized for heating the water. The pumping, however, represents compulsory live-steam operation and none of this heat is available for power.

It is assumed that the 15 lb. per kw.-hr. under 28 in. vacuum is obtained with steam at 150 lb. gage and 100 deg. superheat, and that the average temperature of the heating medium is 150 deg., permitting a vacuum of 20 in. and a temperature of 160 deg. for an average outside temperature, of, say, 32 deg.

The data for loss in the mains for the three systems are given in Tables 1, 2 and 3. The water system has an average assumed temperature of 160 deg., although the actual variation would be from 100 to 215 deg., depending on the outside temperature.

Mr. Ballard mentions the nonconductivity of the ground, although the efficiency of the covering is almost what is found when the pipes are covered and surrounded by air. This is made up in part by the high specific heat and density of the surrounding earth. High absorbing power is nearly as great a source of loss as great conductivity, although constant heating will eventually raise the ground temperature and reduce the loss.

The tables show under the assumed conditions the line loss on the high-pressure steam system to be 1,749,982 B.t.u. per hr., on the low-pressure steam system 2,491,776 B.t.u. and on the hot-water 2,341,418 B.t.u. per hr. The high-pressure steam system will have a nearly con-

TABLE I. RADIATION FROM MAINS OF LOW-PRESSURE STEAM SYSTEM

Size In.	Sq.Ft. per Ft.	Length Ft.	Sq.Ft. Surface	Steam Temp. Deg. F.	Steam Temp. 40 Deg.	B.t.u. per hr. per Sq.Ft.	B.t.u. per hr. Bare Pipe	15 per cent. Loss B.t.u.
24	6.238	2000	12,476	247	207	414	5,165,064	774,760
22	5.76	2000	11,520	241	201	402	4,631,040	694,656
18	4.71	2200	10,362	236	196	392	4,061,904	609,286
14	3.662	2000	7,324	228	188	376	2,753,824	413,074
Total..								2,491,776*

* 2492 lb. steam.

TABLE II. RADIATION FROM MAINS OF HIGH-PRESSURE STEAM SYSTEM

Size In.	Sq.Ft. per Ft.	Length Ft.	Sq.Ft. Surface	Steam Temp. Deg. F.	Steam Temp. 40 Deg.	B.t.u. per Hr. per Sq. Ft. @ 2 B.t.u.	B.t.u. per hr. Bare Pipe	15 per cent. Loss B.t.u.
10	2.82	4000	11,280	344	304	608	6,858 240	1,028,736
8	2.257	2200	4,965	327	287	474	2,849,910	427,486
6	1.8	2000	3,600	312	272	544	1,958,400	293,760
Total...								1,749,982*

* 1750 lb. steam.

TABLE III. AVERAGE RADIATION FROM HOT-WATER MAINS

Size In.	Sq.Ft. per Ft.	Length Ft.	Sq.Ft. Surface	Steam and Water Temp. Deg. F.	Water Temp. 40 Deg.	B.t.u. per Hr. per Sq. Ft. @ 1.8 B.t.u.	B.t.u. per Hr. Bare Pipe	15 per cent. Loss B.t.u.
18	4.71	7000	33,970	160	120	216	7,337,520	1,100,628
14	3.662	8000	29,296	160	120	216	6,327,936	949,190
12	3.333	2700	9,000.	160	120	216	1,944,000	291,600
Total..								2,341,418*

* 2341 lb. steam.

stant line loss, the greater line loss occurring at periods of low load on account of the increased pressures and temperatures due to lower velocities and volumes. The same is true in a less degree of the low-pressure steam system, while the loss on the hot-water system will vary from 50 per cent. greater loss in extreme weather to 50 per cent. less in moderate weather and periods of light load, that is, the loss will vary with the actual amount of heating required.

The condensation from both steam systems is of necessity wasted to the sewer while all is saved on the water system at nearly the same temperature that the steam is used in the heaters. Drain traps are generally a continual source of waste unless a force of men is maintained to keep them in proper operation. They release the water at the temperature corresponding to the steam pressure whether high or low, and the heat in the liquid is wasted. At 50-lb. pressure the water would leave the mains at about 300 deg.

In the high-pressure steam system with the great drop in pressure it would hardly be safe to omit drain traps on the mains. If the consumption of heat were low the pressure would increase, reducing the velocity, and water at a high temperature would collect due to the line loss. If a large amount of surface were turned on suddenly this water would likely cause water-hammer. It would flow along the pipe, holding its temperature until a condition of lower pressure were reached, when a portion would reevaporate. In any case the repair bills in such a system would go a long way toward balancing the loss by radiation on the hot-water system which will have the lowest repair account if properly installed at the start.

The maximum heating load will be assumed to be 75,000,000 B.t.u. per hr. and the average load will be

bout 60 per cent. of this. The factor for the water system should be taken at about 55 per cent., due to the greater flexibility of the heating medium, but for ease of comparison both systems will be taken at 60 per cent. at a maximum rate of 0.3 lb. of condensation per square foot per hour on the steam system in zero weather, a connected load of 250,000 sq.ft. could be carried. The water system would require about 10 per cent. more surface at a lower rate of steam consumption to heat the same space. The average load on either system in pounds of steam per hour would be

$$75{,}000 \times 0.60 = 45{,}000 \; lb. \; per \; hr.$$

In comparing the two systems the steam system will be figured from 125 lb. gage to 50 deg. feed temperature and the cost of all water for heating will be charged. As 20 in. of vacuum will be carried on the water system in average heating weather, the feed water will be 160 deg. temperature and an initial pressure of 150 lb gage and 100 deg. superheat will be assumed as the requirements for a rate of 15 lb. per kw.-hr. at 28 in. of vacuum. It will be assumed that the steam pressure is reduced to atmospheric on the steam system and the condensation leaves the system at a temperature of 212 deg. This will not be quite true in practice as it will probably be higher. The total heat at 165 lb. absolute and 100 deg. superheat in a pound of steam is 1252 B.t.u. and the heat in the liquid above 32 deg. at 160 deg. is 128 B.t.u., leaving 1124 B.t.u. as the total amount of heat introduced per pound of steam on the water system.

For the steam-heating system the total heat at 140 lb. absolute is 1192.2 B.t.u. per lb., and the total heat in the liquid above 32 deg. at 50 deg. is 18. Thus 1174 B.t.u. per lb. of steam is introduced. Even if exhaust steam is provided from some source to heat the feed water in the case of steam heating, this heat should be charged in making a fair comparison.

The amount of heat actually introduced, including power and heating on the water system, is 50 B.t.u. less than on the steam system. The loss in the mains per pound of steam distributed under average conditions for the steam system would be

$$\frac{1{,}749{,}982}{45{,}000} = 38.9 \; B.t.u. \; per \; lb.$$

The loss on the water system would be

$$\frac{2{,}341{,}418}{45{,}000} = 52 \; B.t.u. \; per \; lb.$$

The total heat in the vapor at atmospheric pressure is 970 B.t.u., which is all that is available for heating. If a higher pressure is used by the customer the loss in the condensation will be greater and the latent heat less. As the condensation is metered the loss is entirely up to the customer. The heat in the steam system available for heating is the total heat of the steam at 125 lb. gage less that in the water at 212 deg. less the loss in the line per pound of steam, or 39 B.t.u. Thus

$$1192 - (180 + 39) = 973 \; B.t.u.$$

is available. The per cent. of heat recovered on the steam system, providing all heat less the calculated line loss is delivered to the customer, would be

$$\frac{973}{1174} = 82.9$$

In the water system the latent heat in the vapor at 160 deg. temperature and 20 in. of vacuum is 1001.6 B.t.u., and deducting the loss in mains of 52 B.t.u., the total heat delivered would be 949.6 B.t.u. per lb., giving an efficiency of

$$\frac{949.6}{1124} = 84.5 \; per \; cent.$$

The amount of heat available for power per pound would be the total heat at 150 lb. gage and 100 deg. superheat, or 1252 B.t.u. less the total heat at 20 in. of vacuum or 1130. This would give for power,

$$1252 - 1130 = 122 \; B.t.u.$$

and the total efficiency would be

$$\frac{949.6 + 122}{1124} = 95.3 \; per \; cent.$$

From these figures the water system is about 2 per cent. more efficient and in addition energy is obtained for power. This difference is due mainly to the loss in condensation to the sewer on the steam system.

The flue-gas temperature would be considerably higher in the case of the superheated steam which is at a temperature of about 466 deg., while the temperature of the saturated steam at 125 lb. pressure is 353 deg. F., a difference of 113 deg. As economizers should be installed in either case for economical operation, the total evaporation should be nearly the same per pound of fuel.

There are 5000 hr. in the heating season, as shown by the weather-bureau reports. The same evaporation per pound of coal, 8 lb., will be used for both steam and water systems. The available kilowatts from the average heating load of 45,000 lb. per hr., will be

$$\frac{45{,}000}{20} = 2250 \; kw.$$

and deducting 365 kw. for pumping will leave as net available power 1885 kw.

Under conditions of the average power load of 1885 kw., utilizing the exhaust steam under partial vacuum, the work of the condenser would not be much over 5 per cent. of the requirements of full vacuum throughout the entire heating season. The condenser is only used to regulate the vacuum on the heater due to fluctuations of both heating and power loads and this regulation can easily be accomplished while other machines are operated on the same condenser at 28 in. of vacuum. When the pumping is deducted the condensing capacity of the heating system is obtained at no expense.

If the heating and power plants were operated separately 5000 boiler horsepower would be required or 2500 for each, as the peak load of both might occur at the same time. With 75,000 lb. of steam per hr. for heating the 2250 kw. would be obtained at a steam rate of

$$\frac{75{,}000}{2250} = 33.33 \; lb. \; per \; kw.\text{-}hr.$$

which would provide for the turbines exhausting at atmospheric pressure or slight back pressure in zero weather. If 1885 kw. net was obtained from the heating steam, the boiler power for 5000 kw. peak power load would be on the byproduct plant

$$\frac{5000 - 1885}{34.5} \times 15 = 1350$$

Instead of 2500 hp.

$$2500 + 1401 = 3901 \; hp.$$

would be all that would be required for both peaks on the

byproduct plant, a saving of practically 1100 boiler horsepower in installation. As these peaks would come at the same instant, only a small percentage of the time the spare boiler power would be more than ample under average conditions.

The cost per horsepower installed for the high-pressure steam system will be as follows:

Boilers	$17
Building	10
Piping	8
Economizer and draft equipment	10
Total	$45

The cost of water at $1 per 1000 cu.ft. on an average load of 45,000 lb. per hr. will be

$$\frac{45{,}000 \times 5000}{62.5 \times 1000} = \$3600 \textit{ per season}$$

The cost of 10c. per 1000 lb. of steam at 8 lb. evaporation given by Mr. Ballard is low for most localities and represents a coal cost per short ton of $1.60. The total investment for the steam system will be:

2500 boiler horsepower at $45	$112,500
Cost of mains as given	65,550
Total	$178,050

Assuming a byproduct plant with an average load of 2000 kw. and 5000 kw. as the maximum, or a load factor of 40 per cent. as per Mr. Ballard's paper, the cost of the hot-water heating equipment will be

Pipe	$52,910
Fittings, valves and expansion joints	17,303
Excavation and back fill	13,000
Miscellaneous material	12,400
Repairing 2000 ft. at $1.20; 13,700 ft. at $1.15	18,155
Conduit and covering	48,566
Steam fitting labor	6,000
Heaters, pumps, piping in power house	30,000
	$198,334
1500-hp. boilers at $45	67,500
	$265,834

In utilizing exhaust steam from power the fuel charge for heating will be the difference in steam required to operate the engines on reduced vacuum at an average in this case of 20 lb. per kw.-hr. and that required to operate the engine for the same power load at full vacuum, or 15 lb. The operation at full vacuum represents the exhaust steam saved for heating. The full rate is charged for the pumping as this is practically live-steam operation.

The cost of operation on the steam system would be

Interest and depreciation, 10 per cent.	$17,805
Extra maintenance on steam system due to steam traps	1,000
45,000 lb. steam 5000 hr. at 10c.	22,500
Water	3,600
Plant labor—three shifts, three firemen at $60 per month for 7 months	5,000
One man in charge all the year at $1200	1,200
Total	$49,905

The cost of operation on the hot-water system would be

Interest and depreciation 10 per cent	$26,583
Cost of pumpage 365 kw.-hr. at 20 lb.—10c. per 1000 lb. for 5000 hr.	3,650
1885 kw.-hr. at (20—15 lb.) 5000 hr. at 10c. per 1000 lb. of steam	4,712
Labor for heating plant—will be three shifts, two firemen for 7 months at $60 per month	2,520
Total	$37,465

This shows a saving in operating cost for the hot-water byproduct over the steam system of

$$\$49{,}905 - \$37{,}455 = \$12{,}440$$

per year, or a saving of 25 per cent. On the difference in investment the $12,440 would pay

$$\frac{12{,}440}{265{,}834 - 178{,}050} = 14.17 \textit{ per cent.}$$

If the price of coal should increase 50 per cent., or to $2.40 per ton, the additional cost of fuel on the steam system would be about $11,250 per year. The total operating expense would then be $61,155. On the water system the additional charge would be $4200 per year, making the total $41,665. Then

$$\$61{,}155 - \$41{,}665 = \$19{,}490$$

$$\frac{19{,}490}{87{,}784} = 22.2 \textit{ per cent.}$$

the saving on the additional investment.

It is well within the realms of possibility that the price of steam coals will increase in cost in a greater ratio than domestic sizes and the analysis shows that this increase in cost of fuel will not detract from the financial standing of the hot-water byproduct plant, while it might reduce the high-pressure steam plant to a nonpaying basis.

If 250,000 sq.ft. is the total connected load on the hot-water and steam systems the cost per square foot per season with coal at $1.60 and $2.40 per ton of 2000 lb. without any profit or administration charge are found in Table 4. The cost per 1000 lb. of steam distributed with an average load of 45,000 lb. of steam per hour is also given for both systems. Taking 7 lb. evaporation as the equivalent efficiency of domestic coal, Table 4 gives the price per ton that the latter would cost to equal the central-station cost without profit or administration charges.

TABLE IV. COSTS WITHOUT PROFIT OR ADMINISTRATION EXPENSES

	Coal $1.60 per ton 2000 lb.			Coal $2.40 per ton 2000 lb.		
	Cost per 1000 Lb. Steam, Cents	Price Domestic Coal per Ton Equivalent to Central Station Cost, Dollars	Cost per Sq.Ft. with 250,000 Sq.Ft. Connected Load, Cts.	Cost per 1000 Lb. Steam, Cents	Price Domestic Coal per Ton Equivalent to Central Station Cost, Dollars	Cost per Sq.Ft. with 250,000 Sq.Ft. Connected Load, Cts.
Steam System	22.18	3.10	19.96	27.2	3.81	24.46
Hot Water System	16.65	2.33	14.986	18.52	2.594	16.7

A successful central-heating plant should be able to distribute the heat to the consumer at a cost including profit and all charges at about the price of domestic coal. In giving the price per square foot per season for the hot-water system it is understood that the steam surface being at a slightly higher temperature than the water will do more work, but as an increase in the connected load would decrease the price per square foot, both water and steam were taken at the same figure. The byproduct plant appears to be the best investment. An increase in steam consumption on the turbine at full vacuum would not destroy the relation as the saving would be greater on the same percentages.

No live-steam operation is charged on the water system and none would be necessary if the power load was as stated. If 50 per cent. of the steam were required direct from the boilers 100 days of 4 hr., or 22,000 lb. for 400 hr. at 10c. per 1000 lb., it would amount to only $880, which would not seriously affect the final conclusions.

✲

In honor of the recent visit made to Germany by the American Society of Mechanical Engineers upon invitation of the Verein Deutscher Ingenieure, the latter organization has prepared a guide book of 171 pages. This book, which is printed in English and German on facing pages, describes the points of interest in each locality to be visited, laying particular stress, of course, on matters relating to engineering and technical education. The itinerary shows that the American delegates arrived at Hamburg on June 19 and that the official visits and receptions terminated at Munich on July 8.

EDITORIALS

N. A. S. E. Convention

The old question, which was presumably settled several years ago, regarding the frequency of the national conventions of the National Association of Stationary Engineers, has been resurrected. Shall they continue to be held annually or only every other year?

At the recent state meeting in Milwaukee, as noted on another page, National Secretary Fred Raven, mentioned the principal argument for biennial conventions, the money saved in railroad fares for the delegates being available for other useful purposes, such as educational work, publicity in relation to the need of boiler inspection and engineers' license laws, etc.

We do not quote the secretary with the intent of giving the impression that he has declared himself in favor of the biennial as against the annual meeting. We do not know his position on the question. We are not sure of our own, but if discussion is in order on the topic we have a few thoughts we would like to submit for consideration.

As Mr. Raven also said the association needs to be uptodate and employ modern methods quite as much as any business institution if it is to progress. On that point certainly all are agreed. Now then, can it be shown that it is better business to adhere to the annual-meeting idea?

Take as an illustration a somewhat parallel case, one related to the advertising policy of a growing business. Here is a man making an excellent product only fairly well known, its worth not being appreciated by a very large share of the possible number of users. Because the orders do not happen to be coming in as briskly as he would like, suppose this man says he will curtail his advertising and save money.

What happens? Well, what happens when any bad conditions are neglected? "The operation was a success—but the patient died." When your steam pressure is falling, you do not cease firing to save money. If you want more steam you must use more coal. If the manufacturer wants more business he must extend knowledge of his product. If the N. A. S. E. wants to continue to grow in size and influence it must keep itself before the public, and is not the annual meeting one very good way of doing this? True, it costs money, but is not this money well invested? If meetings were held less frequently, would not the actual receipts of the association dwindle by more than the difference saved?

To say nothing of the other benefits of the conventions, their educational value, extension of the individual's circle of acquaintance among those identified with the same profession, promotion of good fellowship, discussion of questions of scientific interest or relating to general welfare of the profession, as by legislation, etc., putting it purely on a selfish, or at any rate commercial basis, do not the conventions attract new members as much or more than any other one thing connected with the association?

No, this line of talk is not forgetting the state conventions that would go on just the same, but there is a far greater enthusiasm brought out by an annual meeting than can be at the state meetings. There is a feeling of pride and gratification that comes into the heart of a man when he gazes about him and sees the hundreds and hundreds of men from all over the country all enlisted in the same contest of harnessing the forces of nature to the will and need of mankind. Rather high-sounding words, but really they do not seem so when one gets to the convention and gets full of that Fourth of July feeling.

As we said earlier in this editorial, we do not wish to seem to be advising one course or the other in the matter. All we are concerned for is the best interest of the association in whatever way it may be served. We are confident that the association's officers will do the wise thing whatever that proves to be. At the present time of writing we are from the extreme interior of Missouri, however, on the question, but we are entirely open to conviction.

Purchasing Coal

In discussion following a paper on boiler-furnace operation, read before the Association of Building Owners & Managers, at its recent Cincinnati convention, the question: "Is it advisable, when buying coal in such amounts as three thousand tons per year, to purchase it on the British-thermal-unit basis?" was asked. Of course, the reader of the paper said it was. Let us see why.

At four dollars a ton (2240 pounds), and using three thousand tons per year, the heat loss due to the difference between coal having an average of 13,500 thermal units per pound and that having an average of 11,000 is 11,760,000,000 thermal units. Considering that seventy per cent. of the heat units in the coal is represented by the water evaporated; seventy per cent. being a fair average under ordinary good operating conditions, the money loss is over fifteen hundred dollars; which is much more than would be necessary to defray the expense of analysis.

The big point about this question is that it is another indication of the fact that many engineers and managers do not make any effort to determine, even approximately, what kind of coal they are buying. So many seem to think because they buy less than several thousand tons of coal per year, that it would not pay to have the fuel analyzed. And because they do not feel justified in doing so, they take no steps whatever to keep track of the quality of coal received, except to occasionally consider the complaints of the firemen after they have repeatedly reported that it is almost impossible to keep up steam with the grade they are using.

One may get the average coal dealer to promise many things when he is after a big order, but unless he is held by something stronger than a mere promise, the grade of coal furnished is likely soon to fall below that agreed upon and furnished in the beginning. How may one know how inferior the coal is unless provided with means to find out? The firemen will not complain until their

work becomes well-nigh intolerable under conditions which they know should not require such hard work if the normal grade of coal were being used.

There are few plants burning so little coal as not to warrant a wheelbarrow and a couple of platform scales for weighing the coal and feed water for making evaporative tests.

It is not necessary to make such evaporative tests elaborate to find out if there is a material difference in the grade of coal furnished. One need simply try to have the conditions the same for one test as for others; differences in the quality of the coal will be readily observed.

The engineers of a community may find it difficult to get the coal dealers to acquiesce to supplying coal on specification, but when the dealers find that those who buy the bulk of their product, are determined to buy it on something more than a "hit-and-miss" basis, they will meet the new conditions.

⁂

New York Smoke Ordinance Unconstitutional

On Friday, July 18, the Court of Special Sessions declared "unconstitutional and unreasonable" Section 181 of the Sanitary and Health Code under which the Health Department of New York City had filed nearly one hundred complaints against the New York Edison Co.

This section reads: "No person shall allow dense smoke to be discharged from any building, vessel, stationary or locomotive engine, or motor vehicle, on any place or premises within the City of New York or upon the water adjacent thereto within the jurisdiction of the city."

The decision reads in part: "The section is unreasonable and arbitrary, because of its unqualified and sweeping character, condemning as a nuisance a thing that may or may not be a nuisance, and because it makes no provision for cases where compliance is impossible."

"The use of furnaces and boilers and the consequent emission of smoke is doubtless necessary to the enjoyment of the ownership of practically every building within the city of New York." As a further reason for calling the section unreasonable the decision states that "it applies generally to all emission of dense smoke and contains no qualifying clause exempting from its operation cases where it might possibly be shown that no known fuel consumer or device could have prevented such discharge."

This latest case again brings out the fact that the smoke ordinance of New York City is little better than no ordinance at all. With all due respect to the court judges they cannot be expected to know as much about the combustion of fuels as do combustion experts, and the interpretation of a smoke ordinance should be in the hands of those competent to weigh the enormity of a violation against the offender's ability to comply.

The press of New York City bewails the decision of the court and urges Commissioner Lederle to appeal the case. The decision may be an ill wind that will blow the city much good.

Every now and then there is a many-voiced protest that this or that company is violating the smoke ordinance. This will continue so long as there is no organized smoke-inspection department to work along lines similar to the one in Chicago.

Commissioner Lederle undoubtedly feels that as long as he is health commissioner he will endeavor to prevent under the present ordinance the presence of smoke which is injurious to health. He also, perhaps, feels that if a smoke-inspection department were created it would not come under the direction of the health department, and for that reason he is not likely to encourage the creation of that much-needed department.

Now that the ordinance has been declared unconstitutional, thereby putting an end to the prosecution of offenders for violation, the Bureau of Municipal Research should bestir itself and investigate the smoke situation and report the necessity for a smoke-inspection department. Otherwise, Commissioner Lederle will appeal the case and, undoubtedly, a higher court will order an amendment of the ordinance to specifically cover points that it now only generally covers.

An amended ordinance will not better conditions so long as there is no recognized department and trained inspectors to coöperate with offenders and assist them in obtaining the smokeless combustion of the lower grades of fuels that must be used under boilers to obtain maximum economy of operation.

Nearly every city of any importance is now taking practical steps to abate the smoke evil. Why should the metropolis of the country, with its millions of population, its beautiful buildings, its many large power houses, employing excellent engineers, and its location which makes easy the procuring of any kind of coal, continue to hold sacred an archaic smoke ordinance?

New York City has the money, the means and the men to organize a smoke-inspection department that will meet any condition of smoke nuisance. It is the social and moral duty of the Bureau of Municipal Research to show the city officials how to organize such a department.

⁂

Two practical articles dealing with the attainment of the highest economy in the operation of steam engines, are to be found in this issue. The first, page 157, declares that valve leakage more than increased cylinder condensation accounts for falling off in economy at light loads. This article is of more concern to designers than operators. Both should be interested in the experiments described on page 159 to determine the effect on economy of varying the compression in steam engines. The results controvert earlier beliefs in that they show that compression up to about 45 per cent. of the initial absolute steam pressure is advantageous. Those who have not already read these two articles will do well to do so, for they are instructive.

⁂

"The thing I like most about my chief engineer," said the general manager of a large plant, "is that when things go wrong he reports them to me, but not until he has remedies for, or has corrected the troubles."

That's the way with all good managers. No one likes a subordinate that waves a red flag in announcement of trouble. It's not so much a question of what's wrong as how soon will things be running again.

⁂

Can anyone tell why in most plants there is one engine or pump, built like the rest, but always giving trouble as though it were hoodooed?

READERS WITH SOMETHING TO SAY

Cutting Pipe under Difficulties

Two pipe bends were ordered for connections from two ew horizontal return-tubular boilers to the main steam eader. Between the header and the pipe bend a 6-in. alve was to be placed, but through an oversight in order- ng the piping the space to be occupied by the valve was ot taken into consideration; consequently the bends rdered were too long. The mistake was not discovered ntil the pipe arrived at the plant. In checking up the iping it was found that the bends were too long by just he length of the valve.

Being anxious to get the new boilers in operation, we eeided to get out of the trouble if possible without re- urning the bends to the makers.

Not being able to swing the bend with the pipe ma- hine in its regular position, we were obliged to stand the nachine on end so that the bend would have plenty of oom to turn. The machine was held in position by be- ng firmly fastened to the floor. The change of position f the pipe machine made it necessary to change the drive hich was easily accomplished. The pipe was cut and hreaded in much quicker time and at less cost than if re- urned to the makers.

ROBERT LOVE.

Baltic, Conn.

Piping for Feedwater Heater

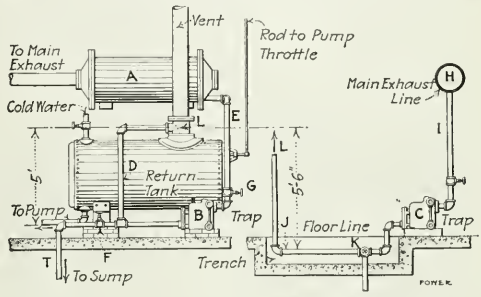
The illustration represents the heater and return-tank ayout of a new plant which is supposed to be in accord- nce with the latest ideas in power-plant design. The oint that I wish to bring out in the installation is the nethod of draining the feed-water heater.

This heater is connected up somewhat different than nost closed heaters. We are all familiar with the closed eater *A* placed in the exhaust line from the engine. After the steam has passed through the heater it goes to he heating system or the atmosphere. In this plant the xhaust is used for heating during the cold weather, the eturns being piped to a vacuum pump which discharges nto the return tank. The pipe supplying the heater with team is taken off at one side and the condensation is upposed to be taken care of by the small pipe which is hown leading to the trap *B*. From the trap it is supposed o flow up the pipe *D* into the return tank and rise to a oint 5 ft. above the trap before it is discharged. By pening the valve *F* this water can be discharged to the ump.

It is desirable to save all the condensate as the cylin- er oil has been separated from it and in this plant the ater has to be purchased from the city. Since the vac- um system of heating is used, there are times when the ressure on the main exhaust line and also in the heater s but slightly higher than that of the atmosphere. Also he heater is located about 115 ft. from the engine so hat there must not be much resistance to the flow of the steam, if any, if it is going to raise the temperature of the feed water to 212 deg. This has been well provided for by an exhaust main of ample size, but the pipe *E* leading from the heater to the trap *B* is only 1½ in., which is large enough if there is sufficient pressure to force the steam through.

Supposing that there is force enough to make the water flow to the trap *B* it is going to require considerable more pressure to force it up the pipe *D* and then over into the return tank. Thus if there were but ½ lb. pressure on the exhaust line there will be a poor circulation in the heater, and this has worked out in practice in just this way, for, although the heater is higher than the return tank, there is enough friction added to the weight of the column of water in the pipe *D* to keep the steam from discharging to the trap *B* unless there is a pressure of at least 2 lb. on the heating system.

When no steam is required for heating, in order to use



HEATER CONNECTIONS IN MODERN PLANT

the trap at all it was necessary to keep the back-pressure valve closed and maintain a pressure of 2 lb. on the engine just to heat the feed water; so the valve *F* was opened and it was found that enough steam would flow through the heater to heat the water at the pressure of the atmosphere, but this caused an offensive amount of vapor to rise into the pump room from the sump well so the piping was changed to better the conditions in this manner.

The riser *D* was removed and the horizontal part of the pipe connected to the pipe *E* at a tee so that when no steam was needed for heating, it could blow through into the heater and what is condensed will be added to the feed while the vapor will be carried to the roof vent pipe. When this is operating in this way the valve *G* is kept closed, but when it is desired to run the heating system, the valve *G* is opened and a valve placed in the connecting pipe is closed and the pipe *F* leading from the trap *B* is continued to the main return line of the system so that the trap will discharge into a vacuum and the water cannot back up, thus keeping the heater always full of steam.

The arrangement at the right was expected to drain the main exhaust line by the pipe *I* which leads into the

trap C and formerly discharged into the return tank through the pipe J, being connected to the vent pipe at the point L. Under very low pressure the trap C was always full of water and did not do its work properly so the pipe J was connected to the main return pipe of the heating system and thus the discharge from the trap C is taken care of and when there is no steam required for heating, the water is allowed to run to the sump through a valve placed at the point K.

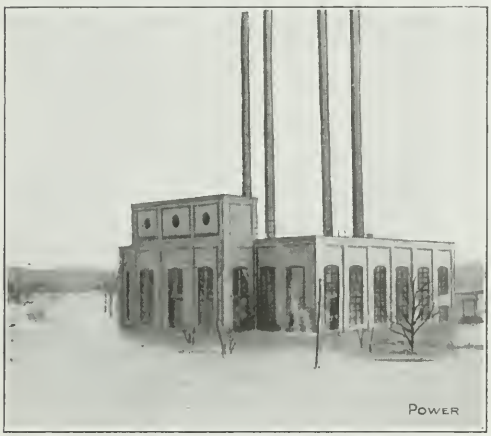
G. H. Kimball.

East Dedham, Mass.

Operating Plant during Flood

The photograph shows the plant of the Electric Light & Ry. Co., of this city, taken at the crest of the flood. At the time the picture was taken, the water was 13 ft. above the engine-room floor, and about 12 ft. above the boiler-room floor.

The water was kept out by bulkheads built in the door



Cribs at Doorways Kept Water out of the Plant

openings. Six pumps were in constant operation, pumping out the water that leaked into the building.

The power plant was in constant operation throughout the flood, which speaks well for the entire operating force, which never left the building during the ten days of the flood.

Frank G. Brown.

Portsmouth, Ohio.

Orsat or CO_2 Recorder Best?

The fact being established that flue-gas analysis is inductive to higher boiler efficiency, progressive engineers are now analyzing flue gases, the majority using either the CO_2 recorder or the Orsat apparatus. There appears, however, to be a difference of opinion as to which of these two is the better. While there remains no doubt but that a recording instrument of any kind is usually preferable to a nonrecorder, the CO_2 recorder as it is today leaves much to be desired. There is only the recording feature to recommend it. While a practically continuous record of CO_2 is desirable, CO_2 alone does not indicate efficiency.

The analyses should show a practical absence of CO as well as a large percentage of CO_2 to indicate high efficiency. As the recorder does not show the CO, which is detrimental to efficiency, using this instrument would, it seems to me, be like taking indicator cards, and omitting the atmospheric line.

The Orsat apparatus, on the other hand, has several features to recommend it. While it does not give a continuous record it can be used to analyze a reliable average sample. If the boilers were operated carelessly, say, several hours during the watch, it would, of course, be almost impossible to tell just when this carelessness occurred, but at the end of the watch the average would naturally be lower than it should be. A sampling bottle properly set up would be more difficult to cheat than a recorder.

With the Orsat a more complete analysis is possible, for it gives the CO_2, the O and the CO. There are other disadvantages about the recorder. One is the fact that the continuous flow of gas through the solution tends to weaken this solution, the result is that after the recorder has been in operation a number of hours, the solution is not strong enough to absorb the entire amount of CO_2 in the gases, and the percentage of CO_2 will vary, though the conditions in the furnace remain practically the same.

There is also the first cost of the recorder to be considered along with the fact that it is a delicate piece of apparatus easily broken when an inexperienced hand gets at it. The Orsat apparatus, on the other hand, costs but little, and one apparatus is all that is necessary, irrespective of the number of boilers. Sampling bottles are cheaply replaced if broken.

A. Pohlman.

Brooklyn, N. Y.

Testing for Approximate Heat Value of Coal

The question sometimes arises as to what will be the cheapest coal to use in a given plant. What coal will evaporate the most water per dollar under actual running conditions?

To answer the above question I have frequently made the following simple test, which may be made in almost any plant without much expense for equipment. This test is of value only as a comparison test as there is an error in measuring the feed water, but this error can be made practically constant for the different tests and its only effect will be to show a greater evaporation than actually takes place, and for this reason I shall call the evaporation as found by this test the apparent evaporation.

The equipment necessary for the test includes scales to weigh coal and ashes, a thermometer placed in the feed-water heater or feed line and a counter for recording the number of strokes of the pump. Before starting the test, see that the pump is properly packed, that the valves are in good condition, that the pump is also in ordinary working order, and that the blowoff valves are tight. The test should cover a period of at least 24 hr.

When starting the test have the ashpits clean and note the condition of the fire and the height of the water in the glass. Note the pump revolution counter, thermometer and steam-gage readings. Repeat these readings

very hour during the test. Weigh the coal used and all h and clinker formed during the test period. At the end the test have the ashpits clean and the height of the re and water the same as when the test began.

The reading of the revolution counter at the beginning the test subtracted from the final reading multiplied y the total pump displacement in cubic inches for one ndication of the counter, divided by 231 and multiplied y 8¼ gives the pounds of water apparently evaporated. he average steam pressure and feed-water temperature re next found by adding together the hourly readings nd dividing by their number. From a table of factors of vaporation the factor for the average steam pressure and eed-water temperature is found and the pounds of water pparently evaporated multiplied by this factor gives he pounds of water apparently evaporated from and at 12 deg. F., which divided the total pounds of coal sed gives the pounds of water apparently evaporated er pound of coal. This result multiplied by the number f pounds of coal that one dollar will buy gives a standrd of comparison.

The percentage of ash and clinker is easily found by ividing the weight of ash and clinker by the weight of he coal.

Myron D. Place.

Foxboro, Mass.

The Value of Graphite

Recently I had impressed on me the good qualities of graphite for cooling and preventing the cutting of engine cylinders and bearings.

The high-pressure cylinder of a horizontal triple-expansion tandem engine gave trouble with the lubrication of both Corliss valves and cylinders when the full superheat of 450 deg. F. with 160 lb. pressure was supplied to the engine which was considerably overloaded. This engine was built about 17 years ago and is not of a favorable design to deal with superheated steam.

It was decided to try mixing a little graphite with the cylinder oil in the proportion of one ounce to the gallon of oil with the results that after nine weeks' application the valves now close quicker and the surfaces of all rubbing parts are very smooth and we now run with full superheat and no signs of the valves or cylinder walls cutting or sticking.

The bearing for an 18x13-in. crankshaft had been adjusted and ran cool for the first hour, after which the "fun" suddenly started. Castor oil, which is used on these bearings, simply ran out like water, or, at least, that ran out which did not go up in vapor. It was seen through the hole in the top of bearing cap that the bronze and shaft were cutting badly, so as a last resource graphite was mixed with cylinder oil in the proportion of a small box (2x2x¾ in.) full to a pint of oil. On pouring in the first dose the results were very pleasing. The bronze immediately stopped tearing and the shaft commenced to polish. This treatment was continued for nine hours, the graphite being cut down to the above quantity added to a gallon of oil after the first two hours, the cylinder oil being gradually cut out after about four hours and castor brought into use. During this time a stream of cold water was kept running on the crank webb and another on the shaft to draw the heat out. No water being put into the bearing. Now this bearing has a better surface than it ever had and is running cooler than before.

The nature of our output requires that the engine be kept running at full speed all the time. We estimated that about $750 was saved by not stopping the engine to cool the bearing, which would have been necessary only for the graphite.

R. Edward.

Rochdale, Eng.

Air-Compressor Trouble

Herewith are diagrams taken from the low-pressure side of a two-stage compressor, with cylinders 18¼x11¼x14 in., compressing air to a final pressure of 100 lb. gage. Lately the intercooler pressure has fallen considerably and varies with the speed, as shown by the diagrams. It is evident that there is a leak on the low-pressure side of the intercooler and I have tried the indicator to see whether or not it would point to the trouble. Before using it the gage was tested on a dead-weight tester and its accuracy assured. Both diagrams were taken from the same cylinder with the same reducing motion, one at

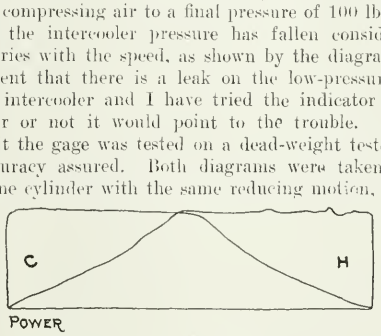


Fig. 1. R.p.m., 25; Scale, 20; Final Pressure, 99 Lb.; Intercooler Pressure, 12½ Lb.

25 r.p.m., and the other at 145 r.p.m. Each diagram fairly represents the extreme condition, as the highest speed of the compressor is about 156 r.p.m. The difference in the lengths of the diagrams is $2\frac{11}{16} - 2\frac{1}{2} = \frac{3}{16}$ in. After taking the diagrams I found that this was due to the cord, which proved to be more or less elastic.

The compressor is running under good conditions, so far as cooling water for jackets and the intercooler is concerned, and the air, when the compressor is running slowly, leaves the intercooler at a lower temperature than the outside atmosphere at this time of the year, and does not rise much, if any, above it when running up to full speed.

The compressor is an old machine, although it is in fairly good condition. The present trouble appears to be

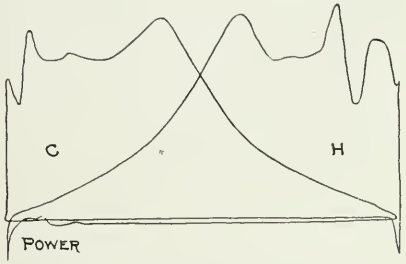


Fig. 2. R.p.m., 145; Scale, 20; Final Pressure, 92 Lb.; Intercooler Pressure, 20

a leak either through the packing or valves. I would be glad to hear from readers on the trouble.

W. L. Shawkey.

Youngstown, Ohio.

ENGINEERS' STUDY COURSE

Heat Lost in Flue Gases—II

Estimating Nitrogen

The flue-gas analysis as made according to the directions given in previous lessons gives the percentage by volume of carbon dioxide (CO_2), oxygen (O) and carbon monoxide (CO). In addition to these there exists water, in the form of superheated steam, nitrogen and sometimes hydrogen and various hydrocarbons. The steam condenses and only a little of it gets to the flue-gas apparatus. All the other constituents except the nitrogen form a small percentage of the total volume. Partly because of this fact and partly because it is difficult to detect and measure them, they are usually ignored entirely. Thus, the difference between 100 and the sum of the percentages of CO_2, O and CO is taken as the percentage of nitrogen (N) contained in the flue gas.

To illustrate, if the flue-gas analysis shows 11 per cent. CO_2, 8 per cent. O and 0.8 per cent. CO, the percentage of nitrogen in the flue gas would be taken as

$$100 - (11 + 8 + 0.8) = 80.2$$

This practice is followed because there is no liquid or chemical solution capable of combining and absorbing nitrogen like CO_2, O and CO are combined and absorbed.

With equal temperature and pressure CO_2 has the same volume as the oxygen required for its combustion. That is, if it requires 30 cu.ft. of pure oxygen at a certain temperature and atmospheric pressure to completely burn a pound of pure carbon the CO_2 formed will have a volume of just 30 cu.ft. when cooled down to the temperature at which the oxygen was measured. The volume of carbon monoxide is twice that of the oxygen required in its formation. Thus, the sum of the percentage of CO_2 and O and one-half the CO should always equal 21 (the percentage by volume of oxygen in the air) when carbon alone is the combustible. But in the average plant carbon is rarely the only combustible in the fuel: it is almost always accompanied by hydrogen.

When hydrogen burns it forms steam which practically all condenses and never gets to the flue-gas apparatus. Thus, the hydrogen sidetracks the oxygen of the air required for its combustion but leaves the nitrogen to pass on to the flue-gas apparatus along with the nitrogen of the air required for the combustion of the carbon. The result is that the sum of the three oxygen constituents of the flue gas (CO_2, O, CO) do not add up to 21, but to some smaller figure, the exact value of which depends, of course, upon the quantity of available hydrogen contained in the fuel.

Using the data given in the last lesson for coal and flue-gas analysis in this lesson, the formula for estimating the weight of flue gases formed per pound of fuel burned works out thus

$$W = 3.032 \times 0.779 \left(\frac{80.2}{11 + 0.8}\right) + (1 - 0.063) = 17 \text{ lb.}$$

Assuming that the temperature of the gases as they leave the boiler is 520 deg. F. and that the temperature of the air entering the furnace is 70 deg., the formula for calculating the heat lost up the chimney in the flue gases would work out thus

$$L = 0.24 \times 17\ (520 - 70) = 1836\ B.t.u.$$

If the coal in the foregoing illustration had a heat value of, say, 13,200 B.t.u. per pound, as fired, the percentage of heat lost with the flue gases would be

$$\frac{1836}{13{,}200} \times 100 = 13.9\ \textit{per cent.}$$

Ratio of Air Supplied to Air Required

It is often desirable to know what the ratio is between the amount of air actually supplied per pound of coal and the amount theoretically required. This can be estimated by means of the following simple equation:

$$R = \frac{N}{N - (3.78 \times O)}$$

where R equals the ratio of the air supplied per pound of fuel to the amount theoretically required and N and O equal the percentage by volume of the nitrogen and oxygen, respectively, in the flue gases, as shown by the analysis.

Using the data previously given the ratio would be

$$R = \frac{80.2}{80.2 - (3.78 \times 8)} = 1.6$$

This means that for every pound of air required by the coal 1.6 lb. was supplied. Hence, the percentage of excess air is

$$\frac{1.6 - 1}{1} \times 100 = 60$$

Measuring Flue-Gas Temperature

Thermometers with a range up to 212 or a little higher are cheap enough that no difficulty need stand in the way of measuring the temperature of the air entering the furnace; that is, the air in the boiler room. But as the temperatures to be measured get beyond 500 deg. F., which is often the case with flue gases, the cost of the pyrometer (the name used for high-range thermometers) begins to be an important consideration. In some plants the expense of purchasing a standard form of pyrometer may not be warranted, in others it may be impossible to show the management the advantage of keeping constant records on the flue-gas temperature. In such cases the engineer may and should for his own benefit provide himself with the means of making an occasional observation of the flue-gas temperature. This he can do at reasonably moderate cost.

Home-Made Apparatus

Numerous means are available but only one will be presented here. The required equipment consists of the bomb shown in Fig. 2, and a chemical thermometer having a range of 1000 deg. F. The latter may be procured of any chemists' glassware-supply house at a cost of from $5 to $10.

The bomb consists of a length of 4-in. pipe capped at one end and a length of ¼-in. pipe extending through the center, as shown, to serve as the thermometer well. Sand is packed in about the ¼-in. pipe and held in place by means of a layer of plastic asbestos at the open end. The length of the pipes is determined by the length of the thermometer. The ¼-in. pipe should be of such a length that when the thermometer is inserted it will be inclosed as high as the 400-deg point on the scale. The 4-in. pipe should be 6 in. longer, as shown. A bail of wire or thin, narrow flat iron attached as shown completes the bomb.

When it is desired to take the temperature of the flue

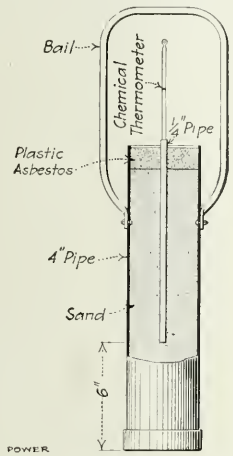


Fig. 2. Sand Bomb and Thermometer for Measuring Flue-Gas Temperature

gases, the bomb (without the thermometer) is hung in the middle of the path of the flue gases as near to the point at which they leave the boiler as conveniently possible. After a half to three-quarters of an hour the bomb is removed and the thermometer inserted as quickly as possible. In a few seconds the thermometer will indicate the temperature of the sand which will be practically the same as that of the flue gases.

Practice Problems

From the following data, estimate the percentage of excess air supplied to the furnace, the number of B.t.u. carried up the chimney by the flue gases and the percentage of loss based on the heat value of the coal.

Proximate analysis of coal, moisture, 4.5 per cent.; volatile, 18.6 per cent.; fixed carbon, 65.2 per cent.; ash, 11.7 per cent.; B.t.u., 13,160. Flue-gas analysis, CO_2, 6.3 per cent.; O, 11.7 per cent.; CO, 0.4 per cent. Temperature of air in boiler room, 75 deg.; temperature of gases leaving boiler, 515 deg.

If the above coal costs $3.10 per net ton (2000 lb.) and if under the present conditions 6200 tons are consumed per year what would be the yearly saving effected if the average percentage of CO_2 were raised to 10.7 and the O reduced to 7.3, other conditions remaining the same?

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Uncle Sam has built a brand new government dredge to be used in the Jacksonville, Fla., district, and, says a local paper, it is equipped with "two Heine compound condensing boilers." Every time we read anything like this we are reminded of William Tell's brother Wat.

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In its "Instructions to Foremen," a mining company says: "If you see a man violating your instructions or taking chances that make him liable to injury, deal with him so as to make it certain he will not again disobey orders." Might order him shot at sunrise or drawn and quartered. If these are irremedial, why not fire him?

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A writer in the "Electrical World," describing the Woolworth Building elevators, says he tested the safety buffers with the car descending at the rate of 1000 ft. per min. and "found it perfectly safe, and in fact, not unpleasant."

Elsewhere he states that if one of the high-lift elevators were to drop from the top of the tower, it would attain a speed near the bottom of the shaft of nearly 140 miles per hour, equivalent to over 12,000 ft. per min. Wonder if the sensation then might be "not unpleasant."

⁂

"Punk, piddy plunk—piddy punk, plunk, plunk,
O, the tail of the spineless pine!"

Something like this crawled in our ears while down to a seaside resortery t'other day and started racing over our tympanums at 1109 r.p.m. Before the end of the 24-hour run, we'll be gormed if we didn't wish the planner, its operating engineer, boiler, flywheel and cylinder head would go up in the air to once. (At the time, we consigned the whole nerve-racking business to another direction —down.) If you're going to take a day off to rest, first find out if the ragtime fiend holds forth in that place; then go somewhere else.

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It's a poor time to borrow money, but a fine time to lend it, says a contemporary. Yes, and it's warmer in summer than it is in winter, and be good and you'll be happy, and— Oh, shucks! It's all right to keep hammering home the truth, but this rubbing-it-in business sure scratches the surface of our good humor. Get something new, or run on your spare units now and then.

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"Some shop grease, with some pay and prospects, is preferable to an unspecked hand that is certain to be empty 48 hours after every payday," says the "Saturday Evening Post." This paper further opines that the clean-collar superstition is slowly subsiding. It looks like the lay press was beginning to understand us. Not long ago, if an able, well-to-do man donned overalls and sported a smudge on his nose, he was either posing or just trying out his one last opportunity to forget that he had more money than he could spend. Now, some of our very best young fellows are toting tin dinner-pails and smearing their aristocratic forms with real dirt. And what shocks many is that the young fellows are enjoying the plunge, are becoming manly men, and are on the right road to learning something useful.

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Goodby to the tungsten lamp if this comes to pass. A West Virginia inventor has a secret chemical bath for the common and garden variety of housefly whereby is produced a light which surpasses the tungsten incandescent. We are somewhat in the dark as to its substitute when this fly has lit out during the long nights of the drear and dread winter —but why anticipate trouble?

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All that has been said about the recent Stamford railroad wreck seems to have resolved itself into the fact that the New Haven road is most culpable in that it allowed an engineer of limited experience to run a fast train unaccompanied. Let us hope that Engineer Doherty will yet be given a fair chance to prove his worth and gain that experience which he undoubtedly has been striving for. Save that kick until he is on his feet.

Heating Engineers Meet at Buffalo

Hotel Statler was headquarters for the nineteenth semi-annual meeting of the American Society of Heating and Ventilating Engineers, which was held in Buffalo on July 17, 18 and 19.

On Thursday morning President John F. Hale called to order the first session and delivered a short address of welcome. The revised laws under which the society is now operating calls for 12 directors instead of 10, so that more work can be done, and he made an earnest appeal to all members for a more hearty coöperation in the association affairs. Routine business, the reports of the Illinois and New York chapters and those of the various committees occupied the entire morning session.

PROFESSIONAL SESSIONS

The first paper, "Time Analysis in Starting Heating Apparatus," was read by Ralph C. Taggart at the opening of the afternoon session. The author showed how to figure the time that is required to warm up heating apparatus. Proper allowance must first be made for the starting of the fire or bringing it up to its normal operating condition. The heat in British thermal units which is given to the iron and water in the boiler before steam is produced was first considered, and then the time required to heat the piping and the radiation in the heating apparatus itself.

Formulas giving the time required in both steam and hot-water systems were developed by the aid of calculus and, to illustrate the use of the equations, certain examples and curves were worked out in the paper.

H. M. Hart followed with a paper on the "Expense of Operating Heating and Ventilating Plants." Methods for computing the cost of operation in advance of construction were given for four different classes of building, namely, residences, apartment buildings, school buildings and office buildings. The data on residences and apartments was conflicting and unsatisfactory. Two school buildings were compared and also two office buildings of about the same size and type, one having its own power plant and the other operating a heating plant only. The former showed a saving of $26,801 over the latter.

In a short discussion on "Ventilation and the Open Window," M. S. Cooley gave some results of tests conducted for the Government at Washington. An interesting paper on "Loss of Pressure Due to Elbows in the Transmission of Air Through Pipes or Ducts," was then read by Frank L. Busey. The author gave the results of two sets of experiments carried on at the testing plant of the Buffalo Forge Co. The first set of experiments was conducted to determine the effect obtained by changing the radius of curvature of the elbow. As might naturally be expected, the loss through a sharp-turn elbow is the greatest, and the loss decreases as the radius of curvature increases. With the radius equal to 1½ diameters of the duct, fairly good results were obtained without making the elbow unduly long; practically nothing was gained by making the radius greater than twice the diameter. The second series of tests was made to determine the effect of reducing the area of an elbow at the throat to the theoretical or equivalent area, the object being to prevent eddy currents along the inner side of the pipe. One source of friction would thus be eliminated and the long-cone effect would aid in changing the accelerated velocity pressure at the turn of the elbow back to static pressure with a minimum loss. With this construction the loss for a standard elbow was reduced as much as 60 per cent.

A paper by Frederick Bass, "Experiment in School Room Ventilation with Reduced Air Supply through Individual Ducts," was the last of the session. In the experiment the air was supplied to each individual desk. During the entire three weeks the test lasted the air was exhausted from the room and used over and over again. Between the exhaust and delivery fans there was an ozone generator and in the equipment there was also provided an air washer and humidifier. The effect on the pupils was closely studied. Each pupil was supplied with about 8½ cu.ft. per min. of renewed air and they were compared mentally and physically with a similar group of pupils receiving 30 cu.ft. of air per min. in an adjoining school. The test results were slightly in favor of the group receiving the smaller amount of air, but it was the opinion of those discussing the paper that although the test was interesting, observations should extend over a much longer period of time before any definite conclusions could be drawn.

TECHNICAL EXCURSIONS

On Friday morning the society as a body visited the Institute of Thermal Research conducted by the American Radiator Co. F. B. Howell, assistant general manager of sales, welcomed the visitors and turned them over to J. H. Davis, L. C. Soule and M. A. May to be conducted through the laboratory. Tests in charge of Dr. C. B. Thompson and L. B. Cherry were being conducted on two house-heating steam boilers, two hot-water houses-heating boilers and on pipe coils under fan blast conditions. Another test was under way to determine the proper size of pipe for one-pipe low-pressure steam systems. A number of radiators containing different amounts of surface were connected by pipes of different diameter to a common supply main carrying 2 lb. pressure. Glass nipples about 12 in. long were inserted in the risers so that any disturbance between the ascending steam and the returning condensation could be noted. The laboratory was well equipped with instruments and facilities for testing all kinds of heating apparatus and the opportunity to look over and inspect this equipment was greatly appreciated by the society.

An interesting afternoon was spent at the plant of the Buffalo Forge Co., J. I. Lyle and W. H. Carrier were there to tell the visitors all about fans, humidifiers, air washers, the various instruments needed in the work and incidentally the method of manufacturing the Spiro turbine.

LAST SESSION

On Saturday there was only a morning session. Professor Allen, past president of the society, who has been in Turkey for the past two years, was present and made a few brief remarks on the progress made by the society. In the early days everything was done by rule of thumb. In the last ten years, however, scientific developments have called for technical men who in the course of time will develop heating and ventilating from a mechanics' art to a science. The first thing necesary is scientific data. The society is beginning to get these data, but there are many things to be learned and a wide field for investigation. For ventilating a room there are no standard methods. It is up to the physiologist to tell first what constitutes proper venilation, and the engineer will then readily fulfill the requirements. Even the amount of radiation required is not definitely settled. It is apparent that there is a tremendous amount of work to be done before heating and ventilation may truthfully be classed as a science.

In England the heating is done mostly by hot water. Practically nothing is known about the single-pipe system of steam heating. The engineers there freely admit that American has gone farther in the development and operation of heating apparatus. In Germany they have developed the theory, but when it comes to practice and installation they too look to America for the latest and best. In doing the work necessary to develop heating and ventilation to a science, Professor Allen looks to a great future for the society.

I. Morgan Bushnell, president of the National District Heating Association, was present and addressed the meeting briefly, referring particularly to the joint committee appointed by the two societies. With the practical knowledge of one and the theoretical knowledge of the other, it was hoped that the combination would produce good results in the solution of the many problems that are now coming to the front. The recent improvements in meters will help greatly in getting valuable data for the solution of some of these problems.

A valuable paper containing a chart for determining the size of pipe for gravity hot-water heating systems was then read by M. S. Cooley. There have been charts for air and steam piping in which all the variables involved could be easily traced, but not for hot water. The method by which the present chart was devised was discussed by the author and its use was illustrated by the solution of several examples.

In a paper on "Heat Transmission with Pipe Coils and Cast-iron Heaters under Fan Blast Conditions," L. C. Soule described a series of 14 tests made at the Institute of Thermal Research of the American Radiator Co. on pipe spaced on 2¾-in. centers. Tests were made on five sections, three sections and one section deep, each section containing four staggered rows of pipe containing 193.1 sq.ft. of surface. The outfit used was placed under test the day before while the society was in the laboratory. The results of the pipe coil tests are all tabulated and the equivalent values in vento heaters given. In comparing pipe coils on 2¾-in. centers with vento heaters it was shown that for the same friction 35 per cent. greater velocity is obtained through the vento than through the pipe coils. This result was obtained when using one stack deep of regular vento on 5¾-in. centers of loops against each section deep of four-row pipe coils.

Chicago is the first city to control the ventilation of buildings, which is done by the ventilation inspection department of the bureau of health. Dr. E. Vernon Hill, who

organized and is conducting this department, gave an interesting talk on his work. Dr. Hill briefly summarized the ordinances as applied to theater ventilation, told how the inspections were conducted and showed by means of lantern slides the card records and some typical installations.

D. D. Kimball gave a list of the members of the ventilation commission of New York City, which was recently appointed by Governor Sulzer and provided with a fund of $50,000. He outlined the scope of the work and described the facilities they would have for conducting experimental and research work.

Routine business and some resolutions of thanks to companies which had extended courtesies to the society ended the session and the convention. It may be of interest to note that the register showed an attendance of 133, of which 75 were members.

GENERAL EXCURSIONS

For entertainment the local committee had provided a good program. Diversions for the ladies in the form of sight-seeing automobile trips in and around Buffalo, including visits to Niagara Falls and to the Roycroft industries established by Elbert Hubbard, were arranged. On Thursday evening the entire delegation had a boat trip to Crystal Beach and on Friday night another boat trip to Grand Island where dinner was served at the Bedell House. A feature was an interesting talk by Professor Allen on conditions in Turkey and the characteristics of its inhabitants. On Saturday afternoon some of the conventioners visited Niagara Falls and the plant of the American District Steam Co., which is in that vicinity.

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Massachusetts N. A. S. E. Convention

The annual Massachusetts State Convention of the National Association of Stationary Engineers took place at Lawrence, Mass., July 10, 11 and 12. The Franklin Hotel was the headquarters. The mechanical exhibit was held in the Armory, which was tastefully decorated and arranged for the purpose. Fifty booths were occupied. The exhibition was formally opened at noon on Thursday. Addresses were made by Albert C. Ashton, president of the New England Association of Commercial Engineers; Claude D. Allen, chairman of the exhibit committee, and State Vice-President Asa M. Day.

On Friday morning at ten o'clock the preliminary exercises of the convention were held in the city hall, R. N. Howard, chairman of the arrangement committee presiding. There were about 70 delegates in attendance. Mayor M. F. Scanlon welcomed the convention to the city of Lawrence, and National Vice-President James R. Coe responded for the engineers. Addresses were also made by F. N. Chandler, Theodore N. Kelsey, Edward H. Kearney, Charles H. Sumner and the Hon. William McComb. State President John T. Maloney then took charge of the meeting, and after the necessary committees were appointed the session adjourned.

The program of entertainment included auto trips about the city, a lecture on the steam turbine by Elmer Smith, of the General Electric Co., and a smoker at the City Hall, where fully 400 engineers and guests gathered. On Saturday afternoon special cars were boarded for a trip to Canopie Lake, where an appetizing banquet was served. The game of baseball between the engineers and supplymen was won by the latter with a score of 12 to 6. The plants of the American Woolen Co. mills were at the disposal of the convention through the invitation of George H. Diman, consulting engineer.

At the final session of the delegates the following state officers were elected: Asa M. Day, president; Thomas Ray, vice-president; John F. Quinn, secretary; Walter Damon, treasurer; Andrew Waite, conductor; Merrick M. Childs, doorkeeper.

The selection of the officers of the New England Association of Commercial Engineers resulted as follows: Bradford L. Ames, president; W. Carleton Barnes, vice-president; Herbert E. Stone, treasurer; Albert C. Ashton, John A. Stitt and F. P. Upson, directors.

During the convention, Albert C. Ashton was presented a handsome traveling bag and toilet set, and Claude D. Allen received a gold watch fob.

The next meeting will take place at Providence, R. I., in July, 1914.

The following is a list of the exhibitors:

Lawrence Machine Co.; W. R. Winn; McLeod-Henry Co.; Manning, Maxwell & Moore; B. L. Ames; George W. Knowlton Rubber Co.; L. A. Couch; Charles A. G. Winther; Hamblett Machine Co.; Wickes Boiler Co.; "Practical Engineer"; Cancos Manufacturing Co.; Philadelphia Grease Manufacturing Co.; Griscom-Russell Co.; Eagle Oil & Supply Co.; J. H. Blanchard; H. W. Johns-Manville Co.; Curry Brothers Oil Co.; Lunkenheimer Co.; Garlock Packing Co.; Bride-Grimes Co.; Economy Lubricating Co.; Autoforce Ventilating System; American Tool & Machine Co.; Calvin H. Currier; Greene, Tweed & Co.; Jenkins Bros.; Ashton Valve Co.; Mason Regulator Co.; International Engineering Works; U. S. Graphite Co.; A. M. Byers Co.; Pennsylvania Flexible Metallic Tubing Co.; Hart Packing Co.; Lumsden & Van Stone Co.; Durabla Manufacturing Co.; Under-Feed Stoker Co. of America; Adam Cook's Sons; Chicago Pneumatic Tool Co.; Robinson Hardware Co.; A. W. Chesterton Co.; Autogenous Welding Equipment Co.; American Steam Gauge & Valve Manufacturing Co.; American Steam Packing Co.; Diamond Power Specialty Co.; F. W. Goldwait; Keystone Lubricating Co.; Evans Mill Supply Co.; Lagonda Manufacturing Co.; Patterson Lubricating Co.; Treat Hardware Co.; Watts Regulator Co.; The Philip-Carey Co.; Enterprise Rubber Co.; "Power"; "Southern Engineer"; "National Engineer"; Archibald Wheel Co.; Callison Brass Foundry Co.; Dearborn Chemical Co.; Monarch Valve & Manufacturing Co.; Crandall Packing Co.; Gardner Gate Co.; A. N. Little Co.; W. J. Hyland.

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Wisconsin N. A. S. E. Convention

The Wisconsin state association of the National Association of Stationary Engineers held its thirteenth annual convention at Milwaukee, on July 10, 11 and 12. Fred C. Ruck, chairman of the local committee, called the first session to order at 10:30 a.m., on Thursday and introduced the Honorable G. A. Bading, mayor of the city, who welcomed the delegates and guests to Milwaukee. In the course of his address, the mayor said that it seemed fitting for the engineers to meet in Milwaukee because of the city's extensive industrial activities and the important part played by the engineer in practically all forms of modern industry.

After mentioning the fact that Milwaukee has an effective engineers' license law, he said he believed that a state law would be preferable as, with such, all engineers would be on an equal basis, while at present engineers coming to Milwaukee from other points must submit to examination before they may operate in the city.

State-President Henry J. Mistele, the next speaker to be introduced, pointed out that it was often difficult for the engineer to get away from his duties long enough to attend a convention and this fact is one of the main reasons why the conventions are not far larger in size. The necessity for the engineer's close application to his duties often works a hardship, as many a man, through thus being confined, has failed to develop all the latent possibilities he possesses, simply because he could not obtain the finish which is to be secured only by contact with other men.

President Mistele also commented on the educational value of state conventions due to the papers and lectures invariably included in the program and the exhibit by the machinery and supply concerns.

National President John F. McGrath said that engineers, like the men in every other line of endeavor, must "make good" to win proper recognition and financial encouragement. He said there were two types of men he did not like. First, the man who takes you down into his engine room, and gives you a long harangue on what a wonderful plant and operating engineer are before you, winding up with the intimation that his only regret is that some day he will die and the boss will have to go out of business because he will not be able to secure anyone to fill the engineer's place. Second, the man who is so lacking in self-confidence that he is afraid that if he loses his position it will kill him because he will never be able to get another one. Dismissal is often a blessing in disguise to such men, for it is the only way in which they would ever be spurred to greater effort.

Charles Cullen, secretary of the Central States Exhibitors' Association, spoke briefly on the exhibits.

Fred W. Raven, national secretary of the N. A. S. E., discussed Milwaukee as the scene of the 1914 national convention. He also touched upon the subject of biennial national conventions instead of annual events, pointing out that the money saved in mileage disbursements to the delegates could well be used for other purposes such as for the educational work, accelerating the enactment of license laws, etc. He stated that the association, just like any business house, must be uptodate and employ modern policies and methods if it is to endure and prosper.

John W. Lane, editor of the "National Engineer," said that an important feature of conventions and meetings is that they bring the individual into contact with his fellow men and help to round him off. Another phase is the opportunity pre-

sented of practicing the expression of his thoughts and ideas while on his feet and in the presence of others. No matter how able a man may be as far as his vocation is concerned, he must be capable of displaying his capabilities to good advantage on occasion if he is to reap fullest benefit from them.

At the Friday afternoon session, J. L. White gave a short paper on "The Operating Engineer as a Political Factor." By way of introduction he explained that he did not favor extreme political activity on the part of the engineer except when laws were involved that related to his occupation. It was asserted that legislation is badly needed to provide for the proper regulation of consulting engineers. Mr. White stated that the public was too often duped by men setting themselves up as consulting engineers when they had little or no suitable qualifications. Where ignorant or inexperienced consulting engineers are employed to lay out or revise plans for a power plant, the operating engineer is often handicapped and placed under a hardship by bungling work. Hence, all operating engineers could profitably concern themselves with the bringing about of suitable corrective legislation.

In the evening, John W. Lane, assisted by Alfred Johnson, gave a lecture on "The Panama Canal," in Miller's Hall. The lecture was illustrated with more than 70 stereopticon views of the various parts and features of the canal, as well as some of the towns and settlements connected with it. Dancing followed the lecture and light refreshments were served.

At the Saturday morning session Prof. Robt. Bauer gave an interesting lecture on "Coal Analysis and the Purchase of Coal on a B.t.u. Basis." The lecturer demonstrated the process of analysis with actual apparatus. Wm. Classman lectured on "The Utilization of Exhaust Steam."

Among the important matters of association business taken up was the question as to whether biennial national conventions should or should not supplant the annual event which is at present customary and a resolution was passed favoring the change.

The officers elected for the present year are A. Gunderson, Sheboygan, president; Fred. Ruck, Milwaukee, vice-president; Robt. Fenn, Sheboygan, reëlected secretary; J. J. Novotny, Madison, treasurer; J. A. Wickert, Milwaukee, state deputy.

The exhibit was held in a large room in the hotel and was, as usual, under the direction and management of the Central States Exhibitors' Association. More than 45 displays were made, some of which were of unusual interest.

While plenty of business and educational work was provided for, the entertainment features were not neglected. The ladies enjoyed an automobile ride on Friday afternoon and a shopping and sight-seeing tour on Saturday morning. On Saturday evening the Exhibitors' Association gave its annual "smoker." Quotation marks are used because the ladies were present and the function assumed so few of the usual characteristics of a smoker that the term is all but a misnomer. Interspersed with addresses by the prominent members of both organizations were elocutional and vocal selections by the entertaining Mr. Fred Hickey, of the Dearborn Chemical Co., his vocal efforts being assisted at times by all present joining in the chorus.

On Sunday the engineers held their annual picnic at Lincoln Grove, Layton Park, where the ball teams representing the engineers and the supply men met in their annual "clash," as the sporting editor would express it, for the punch-bowl trophy donated two years ago by H. S. Bowers. The score was 11 to 9 in favor of the engineers, who, thereby, won the trophy from the supply men who were victorious last year. Other features of the picnic were races and games for boys, girls, women, fat men, engineers, supply men, etc., and a tug-o'-war between the engineers and supply men, which was won easily by the former.

The place for the next convention will be selected later by committee.

OBITUARY

Anthony N. Brady died in London, England, on July 22. Mr. Brady was a selfmade man, and from a very humble beginning rose to be a power in the financial world and the head of many large corporations. Among them were the New York Edison Co., the Edison Electric Illuminating Co., Brooklyn, and the Kings County Electric Light & Power Co., and many more. He was chairman of the board of directors of the Brooklyn Rapid Transit Co., trustee of the Consolidated Gas Co., of New York, director of the Hudson & Manhattan R.R. Co., and director of the United States Rubber Co. Mr. Brady was born in France of Irish parentage, 70 years ago. He leaves a widow, two sons and three daughters.

BUSINESS ITEMS

The American Engineering Co., Philadelphia, has just issued three very interesting booklets entitled, "Morning," "Noon" and "Night," in connection with the Taylor stoker publicity. Copies are sent free on request to anyone interested in stokers.

A very interesting booklet has recently been issued by Greene, Tweed & Co., 109 Duane St., New York, which shows some of the buildings in and around New York in which Rochester automatic lubricators are installed. It's worth sending for.

Delegates and Visitors at the Wisconsin State N. A. S. E. Convention, Milwaukee, July 11, 12 and 13, 1913

The Griscom-Russell Co., 90 West St., New York, has established its own New England office in Boston, 141 Milk St., to take care of the growing demand for Griscom-Russell specialties in New England. Mr. Wm. A. Evans has been appointed manager of the new office.

Owing to the increase of their business in New England, Schutte & Koerting Co., 12th and Tompson Sts., Philadelphia, have moved their Boston office from 98 High St. to larger quarters at 132 High St. The Denver office has also been moved from 1710 Glenarm St., to the First National Bank Bldg.

The American Pulley Co., Philadelphia, has moved its New York branch from 203 Lafayette St. into more commodious quarters at the corner of Grand and Green Sts. At the new address is carried a complete stock of "American" belt pulleys. Orders will be received for reels, spools, beams, sash pulleys, and pressed-steel shapes.

The Western Kieley Steam Specialty Co., 116-122 West Illinois St., Chicago, has published a new 96-page catalog illustrating and describing its various steam, air and water regulating appliances. In addition to the Western-Kieley goods, the company has added the Boylston line, and this is fully described in the new catalog, a copy of which is sent free on application.

"A Collapsible Oil Filter" is the title of a new booklet published by S. F. Bowser & Co., Fort Wayne, Ind., illustrating and describing the Bowser oil filtering and circulating

POWER

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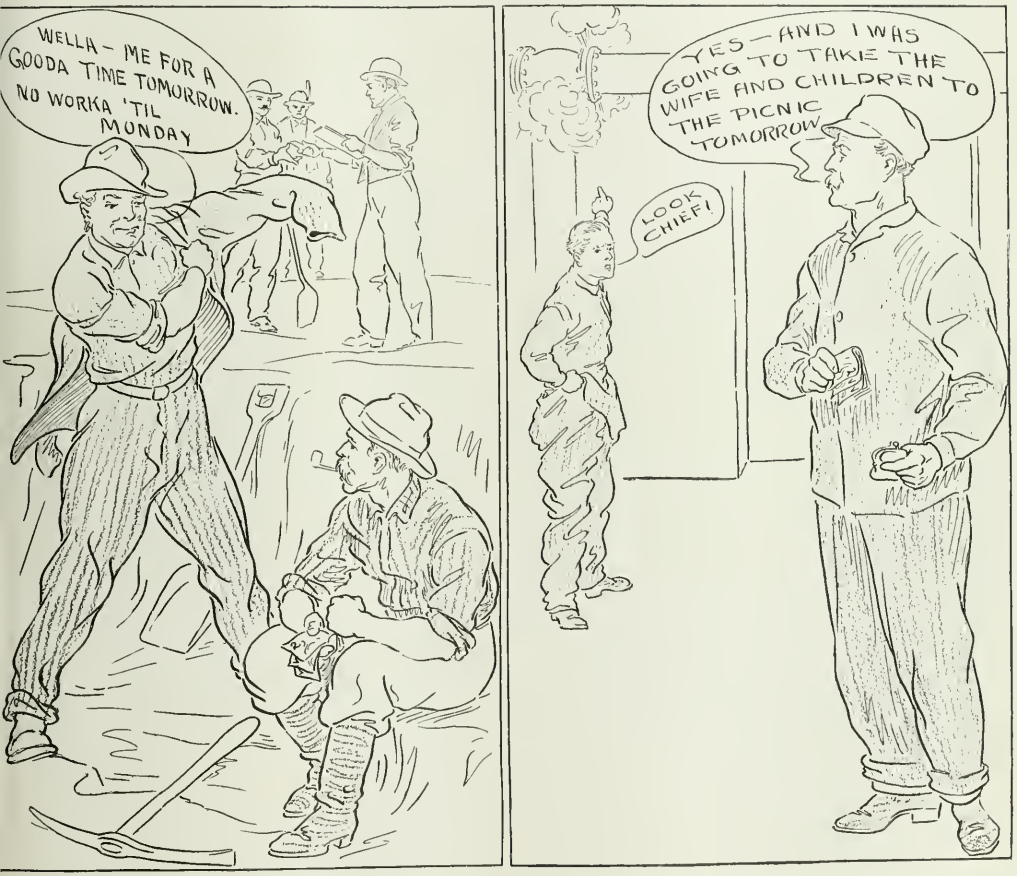

WELLA - ME FOR A GOODA TIME TOMORROW. NO WORKA 'TIL MONDAY
YES — AND I WAS GOING TO TAKE THE WIFE AND CHILDREN TO THE PICNIC TOMORROW
LOOK CHIEF!

WHERE THE DAY LABORER HAS IT ON THE ENGINEER.

Power from the Mississippi River

SYNOPSIS—Three hundred thousand horsepower obtained at Keokuk by a dam, creating 32 ft. mean head, and Francis-type turbines of 86 per cent. efficiency. Power is transmitted as far as St. Louis, 144 miles distant, at 110,000 volts.

The average person thinks of the Mississippi River as a sluggish stream of muddy water flowing evenly its 2500 miles to the sea. Of such a stream one would scarcely suspect water-power possibilities, for when thinking of water power it is natural to picture a majestic fall, as at Niagara or Snoqualmie, or a plant with an Alpine set-

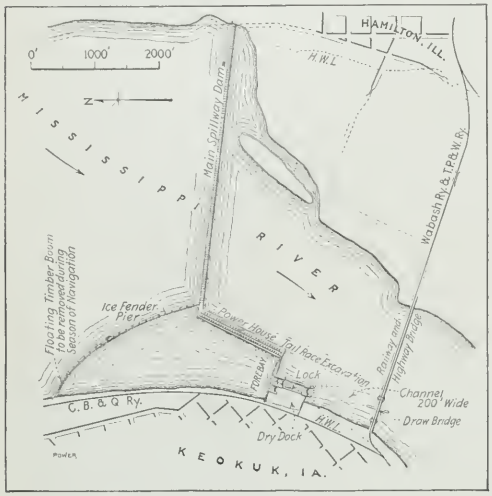


FIG. 1. MAP OF DAM, POWER HOUSE, DRY DOCK AND LOCK

ting, everlasting mountains forming a background. Yet, on the Mississippi, at Keokuk, Iowa, the Mississippi River Power Co. has erected and just put into operation a water-power plant of distinguished proportions and noteworthy features with a power output by far the largest in the world.

Ultimately, this plant will have a capacity of more than 300,000 hp. or over 231,000 kw. This vast amount of energy is to be obtained by making the greatest river in North America pass a large share of its 20,000 sec.-ft. minimum flow, or 372,000 sec.-ft. maximum, through 30 turbine-obstructed concrete tubes, 18 ft. in diameter, in a power house 1718 ft. long; or approximately one-third of a mile.

For about 12 miles up river from Keokuk the Mississippi forms what are known as the Des Moines Rapids, the total descent of the river in that distance being about 23 ft., or greater than that for any similar stretch elsewhere in the river. Added to this essential—an appreciable fall within a comparatively short stretch—the location offered the advantage of bluffs close to the river on both sides for a considerable distance above the dam site, thus reducing the area overflowed by the erection of the dam. And finally, the river bed was found to consist of blue limestone of excellent quality, thus providing an excellent natural foundation for the dam, power house, etc.

A government canal extending nine miles around the lower part of the Des Moines Rapids served heretofore to assist boats past this turbulent stretch of water. With the completion of the dam this canal and its set of three locks was inundated by several feet of water. Some of the conditions imposed by the national government before permission was given to build the dam and power house were that navigation should not be interrupted and that a lock, to take the place of the now useless canal and locks, and a dry dock, be provided by the company, together with the necessary motive power in perpetuity to operate lock, dry dock and the machine shop connected with the latter.

Thus, it comes about that integral with the dam and power house are one of the largest locks in the world and the largest dry dock in fresh water. These were designed and constructed under the scrutiny of war-department engineers and upon completion were turned over to the United States without cost.

The erection of the dam causes the formation of a pool or lake, from 1 to 3 miles wide, for 65 miles above the dam, with a depth at its lower end of over 40 ft. and at its upper end, 8 ft. The substitution of one large lock for the three smaller ones and the elimination of the canal, in the passage of which boats were compelled to proceed at low speed, have reduced the steaming time between Keokuk and Montrose by about 2 hr., a gratifying development to river men.

THE DAM

In Fig. 1 is given a diagrammatic plan of the work while a panoramic view is offered in Fig. 2. The dam, stretching practically out of sight across the river, looks more like a heavy masonry or concrete bridge. And, in actuality, that is what it is—a series of massive piers connected at the top by a causeway. What makes a dam of it are the thick webs of concrete rising 32 ft. between the piers at the bottom with adjustable steel gates above which hold back the water and create a difference in level of from 29 to 41 ft., depending on the condition of the river and the position of the gates.

The dam, of the gravity type, maintains its stability against the pressure of the water by sheer weight alone, and is of massive concrete without reinforcements.

The length of the dam is 4278 ft. which, with a 290-ft. abutment at its east and an 81-ft. abutment at its west end, makes a total of 4649 ft., or 88 per cent. of one mile. There are 118 piers, 6 ft. thick and 53 ft. high. At the top, these are 29 ft. wide and at the bottom 42 ft.; all the taper is given to the down-stream faces, the up-stream ones being plumb. The distance between piers is 30 ft. in the clear. The arched causeway across the top is 29 ft. wide. This may be used as a double-track railroad bridge, if desired, by making a short connection with the shore at the west end.

The normal depth of the river being about 7 ft., cofferdams were employed for all parts of the work as the cheapest means of construction. Some preliminary statistics and views were given in POWER for Sept. 5, 1911.

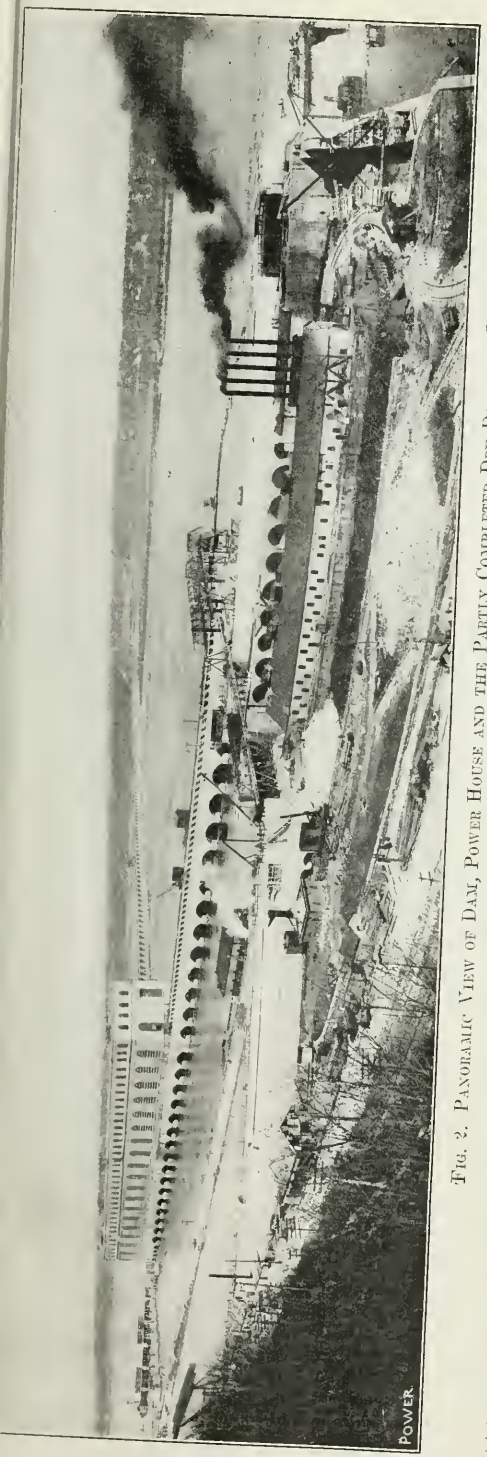


FIG. 2. PANORAMIC VIEW OF DAM, POWER HOUSE AND THE PARTLY COMPLETED DRY DOCK AND LOCK

The power house, lock and dry dock are located in the river close to the Iowa shore. The power house lies practically parallel with the river and nearly at right angles with the dam. The area between the power house and the Iowa shore serves as the forebay, the down-stream end being composed of a short dam wall, the lock and the dry-dock area, as shown in Fig. 1.

At the opposite end of the forebay a concrete ice fender extends 2625 ft. from the dam to the shore. A 300-ft. break in this fender is provided near the shore to permit the passage of boats to and from the dry dock and lock. In the ice season, this break is closed by a floating boom, so designed as to have a draft of 5 ft., thus effectively obstructing even an extensive floe of ice or mass of drift wood. The concrete portion of the ice fender is composed of piers 10 ft. thick on 70-ft. centers, connected at the top by concrete spans extending 4 ft. below the mean low-water level and 5 ft. above the mean high-water mark.

Owing to the vast amount of work and material involved in the erection of this plant, and, hence, the huge sum of money required, speed in construction was of cardinal importance for the sum representing the interest on the money expended for prosecuting the work kept growing in ever increasing proportions. For this reason it was good business to make the most elaborate preliminary arrangements and provide an ample and efficient construction force and equipment to insure rapid work.

The work was carried on in two sections. One force started the dam at the Illinois shore and worked west to connect with the power plant which, with lock, dry dock and ice fender, was erected simultaneously with the dam by another force.

The first 36 spans of the east end of the dam were built on a meadow intervening between the normal shore of the river and the bluffs and for these no coffer-dam was needed. Coming to the river, a sectional coffer-dam 78 ft. wide was constructed, as required, the first section to be put down being about 1000 ft. long. Subsequent sections ranged in length from 400 ft. up. A complete pumping plant containing two 6-in. centrifugal pumps of about 1000 gal. per min. capacity, was used for pumping out the various sections of coffer-dam-inclosed area.

The first operation in constructing the dam was to blast out a slot in the bed rock floor of the river several feet deep and as wide as the base of the dam itself in which the solid concrete work of the huge monolithic structure was commenced. Thus, the dam was firmly keyed in position. Next, the solid concrete piers and overhead connecting arches were "poured" into their steel molds. As a section of the concrete hardened, the forms were removed and used again. A partition wall was thrown across the coffer-dam between the finished and unfinished work and the section of coffer-dam thus rendered unnecessary would be destroyed. Coffer-dam material was economized and the least possible obstruction was made to the flow of the river, the spaces between the piers being left clear for the water to flow through.

On the site of the power house, dry dock and lock a large coffer-dam was put down and pumped out, unwatering an area of 35 acres. After the completion of these structures the work of building up the dam between the piers was commenced. This was done by first putting

down what are known as stoplogs so that the space between a pair of piers was closed off and could then be pumped out. Next, the concrete for the web between the piers was poured into position, and, although the completed height of this web is 32 ft. above the river bottom, a layer of only 5 ft. was put down at one time and the space between, only one pair of piers was blanked off. In this way the dam was gradually built up with

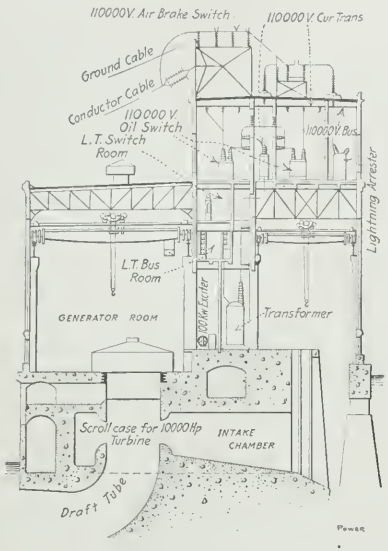


Fig. 3. Diagrammatic Cross-Sectional Elevation of the Power House

the minimum of resistance from the river. The up-stream face of this web is vertical, but the down-stream side has the form of an ogee curve so that water running over the crest of the dam will do so with the least noise and disturbance.

Lock and Dry Dock

The lock and dry dock are built integral with the power house and dam. The former has the same width as those in the Panama Canal, 110 ft., and is 400 ft. long inside the chamber. The dry-dock basin is 150 ft. wide by 463 ft. long.

The lower gates of the lock are 50 ft. high, providing for a maximum lift of 40 ft. in contrast with a 32-ft. maximum at Panama. They are hinged at the sides and swing inward in the usual manner.

The upper gate is of special design and of a type that raises and lowers. Its lower portion consists of a rectangular steel box open on the bottom for the admission of water; the upper portion is a framework of structural steel faced on both sides with plates which join the box part at the bottom and are water-tight at their joints, thus forming the actual gate surface. This gate fits into a slot and is provided with rack and pinion at each side, the pinions being connected by a shaft extending across the gate, to prevent jamming due to uneven raising or lowering. To raise the gate, air is forced into the lower part which drives the water out through the bottom. In lowering, the operation is reversed, the air being released by changing a set of valves. A second or guard gate is provided for emergency use. These two and a third gate, employed in the dry dock, are interchangeable and so arranged that they can be easily floated from one position to another when desired. With the lock gate in its lowered position there is a clearance of 8 ft. of water above it which is ample for any boat on the river.

Power House

Only 859 ft., or half of the power house, has been completed. The other half will extend from the present half down stream almost to the lock, which is seen in partly completed condition at the right in Fig. 2. The width of the power house is 132 ft. 10 in., and the height, including the under-water section, 177 ft. 6 in. What is known as the substructure portion, containing the intake tubes, turbines and draft tubes, is 70 ft. high from the bottom of the foundation to the dynamo floor. The foundation extends 25 ft. below the river bottom and is set in an excavation in the solid limestone. The superstructure contains three floors for transformers, busbars and switches. The diagrammatic cross-section in Fig. 3 shows the general arrangement of the apparatus. The substructure is of solid concrete: the walls are of rein-

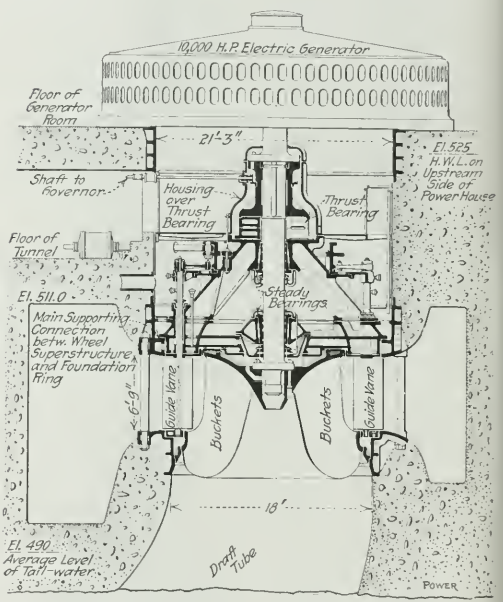


Fig. 4. Vertical Section through One of the Units

forced concrete and the floors and roof are of structural steel and reinforced concrete.

Generating Equipment

The present generating equipment consists of 15 Francis-type turbines nominally rated at 10,000 hp. driving 7500-kw. vertical dynamos. In the completed power house there will be 30 such units. A general interior view of the dynamo room is given in Fig. 5.

The turbines are of special design, being unusually large and operating under unusual conditions. Half were

FIG. 5. INTERIOR OF GENERATOR ROOM JUST BEFORE THE FIRST UNITS WERE READY TO BE STARTED

uilt by the I. P. Morris Co. and half by the Wellman-eaver-Morgan Co. The best practice and knowledge on ater turbines of Norway, Switzerland, Germany, France, taly and America were drawn upon in designing these urbines, and, as a result, an efficiency of 86 per cent. by Iolyoke test has been attained. This is exceedingly high, n fact, it is claimed as a world's record. The usual effi-iencies range between 75 and 80 per cent.

While the normal actual capacity of each turbine is little over 10,000 hp., the overload rating is 13,000 p. These values are based on a head of 32 ft. and a peed of 57.7 r.p.m.

The runner is 16 ft. 2 in. in outside diameter and arries 20 blades, 6 ft. long by about 3 ft. wide. It is ung on a 25-in. shaft which passes up through the enerator floor and carries the rotor of the dynamo on its pper end. A single huge thrust bearing is located be-ween dynamo and turbine, as shown in Fig. 4, to support he entire weight of the revolving parts, some 550,000 lb. Below are two steady bearings to hold the revolving parts n position. All bearings are above water, making them asily accessible and simplifying the problem of lubrica-on. The thrust bearing is of the roller-bearing type and s provided with means of forcing a sheet of oil between he two faces at a pressure of 250 lb. per sq.in. to float he load and obviate the need of the rollers. An attempt will be made to operate without the high-pressure oil, using the rollers only. If this proves successful and economical, the oil will be used only in emergencies.

A set of guide vanes, surrounding the runner and connected with two oil-operated pistons, adjusts the water supply to the runner in accordance with variations in electrical load and hydraulic head. The movement of these vanes is controlled by a Lombard governor. A cross-section showing the general construction and arrangement of each unit is given in Fig. 4.

There are four water-inlet passages, Fig. 6, to each turbine, three of which unite a short distance from the inlet to form the larger portion of the scroll chamber, the fourth forming the remaining portion. Each passage is fitted with headgate and screen. The shape and dimensions of these water passages and the scroll chamber were carefully planned so as to deliver the water to all points on the circumference of the turbine at a uniform velocity, thereby securing maximum efficiency.

The draft tube is 18 ft. in diameter at the point where the water leaves the runner and gradually changes in shape until it is an oblong rectangle with circular ends at the point of discharge to the tailrace, 22 ft. 8 in. high and 40 ft. 2 in. long. The entrance velocity of the water is 14 ft. per sec. and the discharge to the tailrace 4 ft. per sec. The turbines are placed 22 ft. below the mean

level of the forebay; thus, 10 ft. of the head is utilized by means of the draft tube.

Dynamos

The main dynamos are of the General Electric revolving-field vertical type and generate 25-cycle, three-phase current at 11,000 volts. The current is distributed at this pressure for local use, but for long distance it is stepped up to 110,000 volts. Because of their low speed the dynamos are of great size, being 31 ft. 5 in. outside diameter with a height of 7 ft. 2 in. at the lowest part.

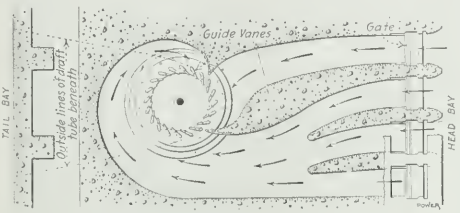


Fig. 6. Plan of Inlet Passage and Scroll Chamber

The efficiency of these generators is 96.3 per cent. at full load and their regulation is 13 per cent. at 100 per cent. power factor. Each machine is fitted with a brake to facilitate bringing the revolving parts to rest when shutting down.

The method of excitation is somewhat unusual. Two 2000-kv.-a. alternators driven by water turbines of the same general design as the main turbines will furnish excitation current for the 30 main generators in the completed station. These feed 25-cycle current at 440 volts to three-phase busbars running the length of the station. From these busbars a 100-kw. motor-generator set is operated for each main dynamo supplying it with current at 250 volts.

For emergency, another 440-volt bus has been installed for each group of 15 units, supplied from the main power busbars through two 600-kv.-a. transformers and all of the motor-generators are arranged for connection with this bus. The voltage of each main generator is controlled by a Tirrill regulator connected with the field of the exciter.

Busbars and Switches

Both high- and low-tension busbars are in duplicate and all dynamos, transformers and lines are equipped with selector switches so that they may operate from either bus. One low-tension bus extends unbroken the full length of the station and is to be used for transferring and in emergency. The other bus, which will be used for normal operation, is fitted with sectionalizing switches and current-limiting reactances so that each outgoing line will be fed from a separate group of dynamos and transformers. Normally, all sections are paralleled through the reactances and the emergency bus joins the ends of the main bus to form a ring.

In addition, there is a low-tension bus for the local 11,000-volt feeders. Fig. 7 shows the general arrangement and construction of the low-tension bus compartments.

Except those for the low-tension bus sections, all switches are nonautomatic and arranged so that trouble in one section causes the opening of the two nearest section switches and through a relay on the voltage regulators, a reduction of the generator voltage.

The emergency and transfer high-tension bus is divided into sections, one for each line. The other is similarly arranged but equipped with section switches so that, if desired, the sections may be paralleled.

The connections between the generators and the low-tension bus room, which is on the second floor, consist of 600,000-circ.mil, single-conductor cables insulated with varnished cambric. The busbars and the current and potential transformers are housed in concrete compartments.

The low-tension switches are directly above the busbars and are also inclosed in concrete cells. These are General Electric H-6 oil-break type, fitted with disconnecting switches in subcells. Connection is made between these switches by solid bars either directly with the busbars or through instrument transformers with the generators and main transformers.

The low-tension circuits are guarded from internal voltage surges by electrolytic static dischargers connected to the various sections. Protection from excessive current is secured by the sectionalization previously mentioned which divides the equipment into ten groups. Connection between these groups is made through current reactances rated at 240 kv.-a. These reactances consist of copper cable wound about three large concrete cores, making a total weight of about 27,000 lb.

Cables similar to those between dynamos and low-tension busbars connect the latter with the transformers which are arranged in a row opposite the generators and on a gallery 8 ft. above the generator-room floor. The

Fig. 7. Low-Tension Bus Compartments

transformers are for three-phase, 25-cycle, 11,000-110,000-volt service and rated at 9000 kv.-a. On the low-tension side they are connected delta and on the high-tension, Y, with the neutral dead grounded. Each transformer is set in a concrete compartment and occupies a space about 8 ft. wide by 16 ft. long and 24 ft. high. The weight is 231,000 lb. each and 10,000 gal. of oil is required.

High-Tension Connections

The connections from the transformers to the high-tension busbars and switches, which consist of 1¼-in.

standard iron pipe, extend vertically to the top floor where the busbars and switches, Fig. 8, are located. These connection pipes are painted copper color for psychological reasons.

The high-tension switches are General Electric K-15 type, triple-pole solenoid operated and of 400 amp. capacity. They are provided with disconnecting switches on one side only, being attached directly to the high-tension busbars on the other.

The high-tension busbars are installed individually in separate rooms and run the full length of the building. These busbars are of 2-in. standard iron pipe hung from the ceiling by seven-unit suspension insulators. The connections from the busbars to the current transformers are of $1\frac{1}{4}$-in. copper pipe. From the transformers the connections pass directly up through the roof bushings. The latter are of special design and afford a factor of safety of three under rain test with line voltage and four when dry.

From the roof bushings the lines run through choke coils to an air-disconnecting switch of the rotary double-break type, mounted 24 ft. between phases and with arms 12 ft. long. Taps to the lightning-arrester horns are made between the choke coils and the disconnecting switches. The horns are connected through roof bushings with electrolytic arrester tanks inclosed in concrete compartments on the top floor of the building.

Switchboard

The switchboard, Fig. 9, is located in a room on the top floor at a point which will be the middle of the building when the latter has been completed. The board is of the remote-control bench type with instrument panels arranged behind the bench. There is a panel of both

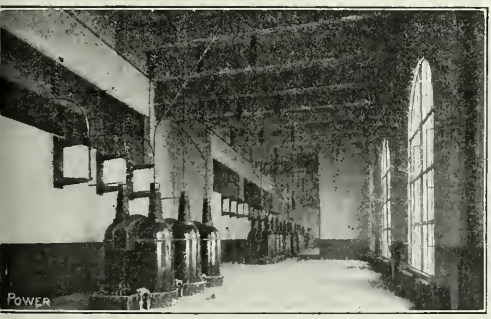


Fig. 8. View of High-Tension Switches and Busbars

bench and instrument board for each main generator and transformer unit and each outgoing line as well as for the exciters.

With the complete equipment in place the board will form a huge U, extending around three sides of the room. In the center of the room is the chief dispatcher's desk and a switchboard. The desk is fitted with a telephone-exchange board and telephone-testing equipment so that complete control is had over the entire telephone system. The switchboard carries a diagram of the bus arrangements and the position of every switch in the station is shown by means of colored lights. In addition, this board is equipped with graphic voltmeters and ammeters for recording the potential and current for each transmission line.

Two storage batteries of 320-amp.-hr. capacity, each, are provided for furnishing the motive power required in the switchboard room. For charging these batteries two 15-kw. motor-generator sets have been provided.

The telephone system is especially complete and provides means for rapid communication with all possible points throughout the station as well as with all substations and points of distribution. Besides the telephone system a signaling system is provided for transmitting the more common operating instructions from switchboard room to each generator unit.

Huge windows spaced on short centers provide ample

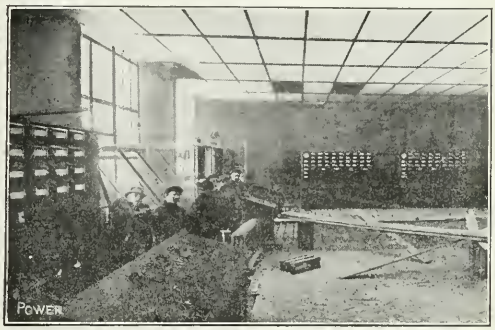


Fig. 9. Switchboard Room Partly Completed

natural light in the main rooms. The artificial light is furnished entirely by tungsten lamps backed with steel reflectors. The lighting current may be taken from either the main low-tension busbars or from the exciter bus through suitable transformers and induction regulators. Approximately one-third of the lights employed throughout the station are so wired that in the case of either under or over voltage they are automatically thrown over onto one of the storage batteries, either of which has capacity for about one hour's service.

The generator room is equipped with two 150-ton traveling cranes and the gate house with a 75-ton machine.

Distribution

For local consumption the current is distributed at 11,000 volts, but for long-distance transmission the current is stepped up to 110,000 volts as before mentioned. Two long-distance lines carried on a single set of towers, Fig. 10, have been run to St. Louis, 144 miles distant, where 60,000 hp. has been contracted for. These lines are of 36,000 kw. capacity, each. Two 27,000-kw. lines have been built to Burlington.

The larger lines, those to St. Louis, are of $\frac{5}{8}$-in. copper cable, of 300,000 circ.mils. These cables are carried on towers averaging 80 ft. high, spaced on 800-ft. centers, by means of suspension-type insulators, each consisting of seven 10-in. disks. These disks are of porcelain and corrugated on their faces. They are strung together by means of malleable-iron fittings cemented to them. This type of insulator was selected after a large number of comparative tests of various types and it possesses a fac-

tor of safety greater than that employed on any other transmission system of equal voltage. The required voltage test is against 440,000 volts.

Price of Current

The Mississippi River Power Co. will sell current only at wholesale in quantities of 100 hp. or more. The announced policy of the company is to encourage manufacturers to locate plants in the section and, hence, a uniform rate of charge for its power is provided for all who use it, regardless of whether the current is purchased direct or through a third party. The maximum demand or service charge is 15c., net, per month per horsepower. Then, the charge for the first 8000 kw.-hr. per month is 1½c. per kw.-hr. For current in excess of 8000 kw.-hr.

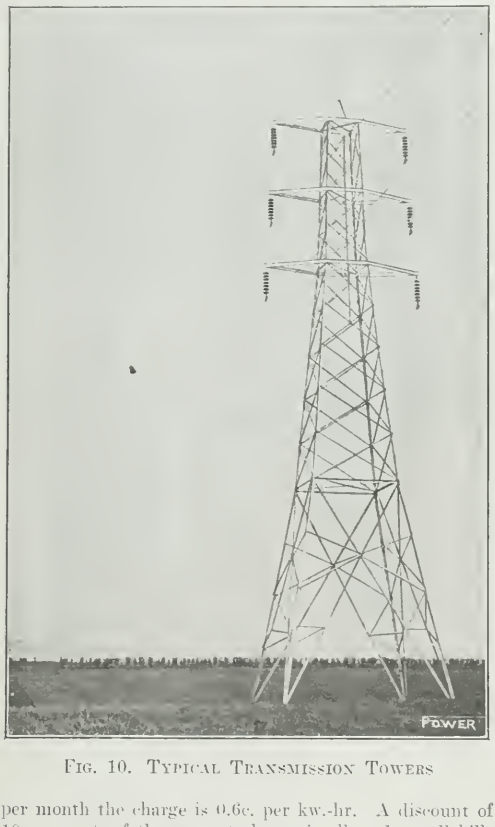


Fig. 10. Typical Transmission Towers

per month the charge is 0.6c. per kw.-hr. A discount of 10 per cent. of the current charge is allowed on all bills paid before the tenth of the month following the month for which the bill is rendered.

The construction of this entire plant, including power house, dam, lock and dry dock, was done by the Mississippi River Power Co. under the personal supervision of Hugh L. Cooper, the chief engineer. No work was sublet to contractors. The Stone & Webster Engineering Corporation, Boston, Mass., had charge of the installation of all the electrical machinery and equipment and the plant is being operated by the Stone & Webster Management Association.

Rules for Boiler Inspection

By J. C. Hawkins

An editorial in a recent issue presents some very good arguments as to why the chief engineer should frequently inspect his boilers and not depend entirely on the insurance inspector.

This has been the writer's practice wherever he had the authority to do so. In one plant which had six water-tube boilers usually loaded to rated capacity, and using a very bad feed water, the boilers were washed every two weeks but were taken off the line to be thoroughly cleaned and repaired, if repairs were needed, about every three months. At these times the boiler was thoroughly examined. This was done in the following manner:

The fire was drawn, and the main steam valve closed. The feed was left turned on a little until the steam had all worked off. The blowoff cock was left open a little to keep the high-water whistle from blowing. The boiler then stood a day or two full of water with all doors closed. Then the grates and combustion chamber were cleaned, also the tubes and all external surfaces of the boiler. Next the drum was opened, and the scale cleaned off, sometimes it could be scraped off, but usually it had to be chipped off. After the drum was cleaned the turbine cleaner was put through the tubes. Boiler compound was not used. After the cleaning came any repairs that were required. Then came the inspection, which was done by the engineer, according to the following directions:

Put on an extra pair of overalls, and go in on the grates with an electric light, a small hammer, and a note book and pencil. The first thing to be looked at is the tubes to note whether there are any bags or blisters, or any that are worse than at the last examination. Notice whether there is any evidence of leaks around the ends of the tubes or stay-bolts. If any are found, make a note of them in the notebook. Next examine the furnace, side and bridge-walls to determine if any repairs are needed. Then look at the front baffle wall; note if it is in good repair, with all the brick in place. Sometimes the space between the tubes on the back side of a water-tube boiler will be found plugged with ashes; look for this by holding the light above the head so that it will shine between the tubes. Next examine the grates and stoker if there is one. Above all take plenty of time in making the inspection.

Next go in above the tubes under the drum, look for bags on the bottom of the drum, also leaking rivets. Tap them and the tubes with the hammer. Hold the light so that it will shine down between the tubes to permit of examining the baffles, also the brickwork around the drum and at the top of the tubes. Make notes of all defects. The next place is the combustion chamber. Examine the tubes for bags, which seldom are found here, also examine the rear stay-bolts and tube ends for leakage. Examine the blowoff pipe, tapping it hard with the hammer, noting if it is solid. Next come the nipples between the headers and mud drum, if there is one. Clean away the scale and ashes and look for external corrosion and leaks, and then examine the rear baffles, which are usually found all right. That finishes this part of the boiler. Then go in above the tubes at the rear ends, see if the tubes are properly cleaned, look at the tube ends and stay-bolts for signs of leaks, examine the baffle walls, and the damper while the helper opens and closes it.

Look for cracks in the setting, especially around the de doors, also see that the doors shut tight, then examine the front and rear doors for air leaks. Go on op of the boiler and examine the setting. Look for leaky ipe joints and leaky valve stuffing-boxes. The safety alve and blowoff valves should be watched for leaks hile in operation. If the safety valve has been leaking, now is the time to regrind or repair it. A leaking lowoff may be found by disconnecting a flange between he valve and blowoff tank, while the boiler is under pressure. Next examine the water column, floats and piping, eed-water regulator, valves and piping, check valves, gage ocks, water-blowoff pipe and valves, etc. This finishes he external surface of the boiler.

Next go inside of the drum, and look for signs of pitting, especially along the water line, also look for scale nd corrosion in all parts of the drum. Tap the braces ith the hammer to see if they are all tight, examine the ud pan and internal feed pipe to see if they are clear, ometimes the feed pipe will be found nearly stopped up ith scale, or it may have become loose in the drum head. ee that the dry pipe is in proper position, and that the oles are clear. Examine the opening to the water colmn and steam gage. Take plenty of time here, as it is ery important. Examine the surface-blowoff pipe conection and come out. Then look after the stay-bolts and ubes in the water leg or header. Have a helper hold a ight at the front end of each tube while you look through from the rear end to note whether there is any loose scale or if the tube is warped. Reach through the handholes with the hammer and tap each stay-bolt to see if it is solid and tight. Examine the tube-cap joints to see whether or not they are in good condition.

This covers the boiler inside and outside, and includes parts that the insurance inspector would not look at very closely. If the tubes are found dirty, some better way of cleaning them may suggest itself to the engineer while making this inspection. Likewise cracks in the setting may suggest a remedy whereby the CO_2 can be increased, and any needed repairs that have been overlooked can be made at this time.

After getting cleaned up, make some sort of a report of the condition found, mentioning each item, while it is fresh in the mind, and compare it with the report of the last examination. Also make a note of repairs that are likely to be necessary at the next shutdown, and the material may be ordered so that it will be on hand when needed. On the first examination all the dimensions of the boiler should be taken for future reference. This need not be done after that except in special cases.

An examination of this kind every three months will keep the engineer posted on the condition of each and every part of the boiler. It is a dirty job, but will make the engineer's work easier in the end, keep the efficiency of the plant at the highest point and will relieve him of many emergency repairs.

❖ ❖

Automatic Regulation of Superheat

YNOPSIS—Controlling superheat temperature by egulating the flow of the hot gases.

❖

The temperature to which steam will be raised in a uperheater, depends upon the design of the superheater, he amount of tube surface, the number of passes which he steam makes through the surface, the weight of steam assing through the superheater, the volume of hot gases assing over the superheater tubes, and the temperature f these gases. Among the possible methods of controlling uperheat temperature are first, to regulate the volume f steam passing through the superheater tubes so that fter it has been mixed with saturated steam from the oiler, the mixture will have the desired superheat, and econdly, to regulate the amount of hot gases passing over he superheater tubes, so that the desired steam temperaure is obtained for any weight of steam passing through he superheater tubes.

The first method is open to the objection that hot gases re always flowing over the tubes, and, therefore, if no team or only a small quantity of steam is passing hrough the tubes they are liable to overheating.

Fig. 1 illustrates the arrangement of Heine superheaters to obtain temperature regulation by controlling the low of hot gases. This figure also shows the automatic ontrol apparatus. The superheater is located in a firerick superheater chamber, forming part of the boiler etting, at the side of the boiler drum. The rear of this uperheater chamber communicates with the furnace by flue, through which a small percentage of the furnace ases rise, making two passes over the superheater tubes, and then flowing out to the front at the bottom of the superheater chamber, where a damper is located.

An automatic temperature regulator controls the damper opening, so as to give constant superheat. This automatic regulator comprises two principal parts, a diaphragm lever, actuated by compressed air, and a thermostat controller which regulates the admission of com-

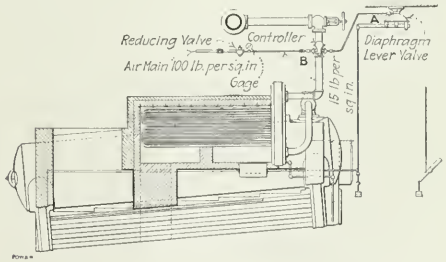


Fig. 1. Arrangement of Superheater

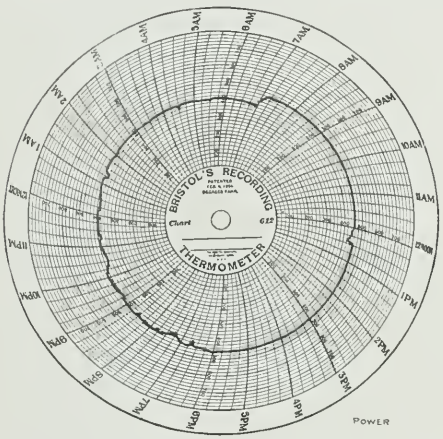
pressed air to the diaphragm lever, in accordance with the temperature of the steam.

The diaphragm lever in this drawing is suspended from a convenient beam; the outer end of the lever is in line with the damper rod, a link connecting the two. Air enters the top of the diaphragm chamber, which is a convex casting with a rubber diaphragm across the bottom. Springs hold a "saucer" against the diaphragm, the saucer itself being recessed to hold a link connecting with the lever. When there is no air pressure within the

diaphragm chamber, the springs press the saucer against the diaphragm and hold it against the inside face of the diaphragm chamber. When air pressure is admitted, it overcomes the resistance of the springs, and causes the saucer to move downward with corresponding movement of the lever and damper.

The controller for regulating the supply of compressed air to the diaphragm lever is installed in the outlet line of the superheater with a thermostat protruding into a suitable fitting. The thermostat consists of two tubes, one of a metal that changes considerably in length with temperature so that changes in superheat cause changes in relative length of the two tubes. This motion causes changes in the opening of a small ball valve which controls the supply of compressed air to the diaphragm lever.

Fig. 2 tells the history of the performance of an automatic superheater regulator of this type. In this plant the load comes on at 7 o'clock in the morning and as the engines and compressors are started, steam is drawn



Performance of Automatic Superheater Regulator

from the superheater, and the superheat temperature comes up to 460 deg., the setting of the regulator. From then on till noon, the superheat remains constant. From 12 to 12:30, the engines are shut down, and no steam is drawn from the superheater, which is acting simply as additional steam-reservoir space. The automatic temperature regulator closes the superheat damper but the temperature of the steam does not immediately fall to boiler temperature, because of the heat stored in the metal of the superheater and the setting. When the load starts up at 12:30, the temperature immediately rises to the normal of 460 deg. and continues until the end of the working day, 6 p.m. During the night, the boiler is idle, and no steam is drawn through the superheater. The temperature approaches that of the steam in the boiler and the superheater damper is tied shut to positively shut off all gases. During the noon hour and at night, the superheater is not flooded.

An advantage of control apparatus with superheaters is that the temperature may be changed as desired after the plant is installed. The thermostat controller has a small dial and adjusting screw, whereby the mean temperature maintained may be raised or lowered as desired. Thus a plant may be operated for a week or a month at 50 deg. superheat, then 75 deg., 100 deg., etc., operating records being kept at the same time of the load and coal consumed. From these records a determination may be made of the most economical working conditions.

Improved Flow Meter

An improved type of flow meter for the continuous measurement of either liquids, gases or vapors has just been put out by the General Electric Co., of Schenectady.

The body of the meter consists of an iron casting cored out so as to form one leg of a U-tube and a reservoir for mercury, the outer leg of the U-tube being formed by a pipe which opens into the reservoir. The pressure on the surface of the mercury varies with the rate of flow of the fluid being measured, as will be explained later.

A float, Fig. 1, rests on the surface of the mercury in the body of the meter and rises and falls with the corresponding changes in its elevation. This float is geared by rack and pinion to a horizontal shaft which carries a permanent U-shaped magnet, the poles of which face a copper cap inserted between the external case and the meter body. A shaft, parallel to the one on which the magnet inside the body is mounted, carries a smaller magnet whose poles are opposite those of the larger magnet, this arrangement serving to transmit motion through the cap without piercing it with a shaft and thus the difficulty of packing such an entrance to prevent leakage is avoided. As the poles facing one another are of opposite polarity, the magnetic flux binds them together s

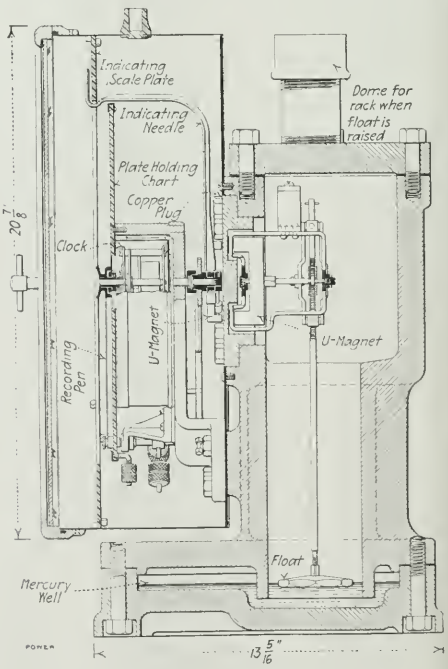


Fig. 1. Section through Meter

lat a movement of the magnet inside the body involves corresponding movement of the one outside, the latter oving the indicating needle and the recording pen rough suitable mechanism.

The pressure which moves the column of mercury in e U-tube is obtained, for pipes 2 in. and greater in iameter, by inserting a modified form of pitot tube rmed a "nozzle plug" directly into the pipe line, see Fig. 2. This can be done without disturbing the piping, except where it is desired to increase the rate of flow at the point of metering, in which case a special pipe reducer *E* is provided. This reducer is made of brass and has a long throat with rounded entrance terminating in a flange. The flange is inserted between the pipe flanges *A* and *B* and is held in place in the same manner as a gasket. A special nozzle plug is supplied with the pipe reducer.

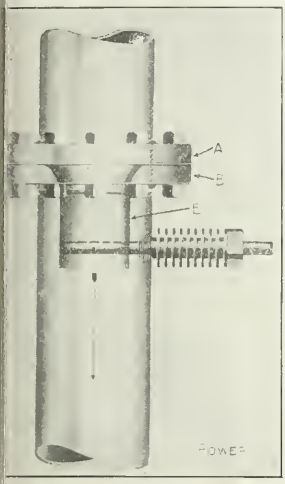


Fig. 2. Nozzle Plug

The nozzle plug is tube with two separate conduits in it, each conduit having a set of openings, the two sets being on diametrically opposite sides of the tubes. Those on the side of the tube cing the flow are called the leading openings, while ose on the opposite side are called the trailing openings.

The flow against the leading openings in the nozzle ng sets up a pressure in the leading conduit which uals the static pressure plus a pressure due to the velocity head. The flow past the trailing openings causes a ction which lowers the pressure in the trailing conuit. As these two conduits are connected to the U-tube ¼-in. pipes, the column of mercury is affected by is unbalanced pressure, causing a movement of the iat. The leading set of openings in the nozzle plug tends approximately across the pipe, so as to make the locity pressure transmitted to the meter the mean velity pressure rather than that at a single point in the pe.

The chart on which the pen records are made is roted by a clockwork at a suitable speed. The recording n sweeps the chart radially and the resulting curve ows the rate of flow at any time during the chart cycle.

The integrating device consists of a stationary flowte planimeter driven by the chart paper. The angular sition of the planimeter wheel is determined by a cam nected to the shaft of the recording pen and moving th this pen; the planimeter dials read in arbitrary its, which, multiplied by a constant furnished with the ter, gives the flow in the desired units.

As previously mentioned, for pipes less than 2 in. in diameter an orifice tube, which is a brass pipe tapered internally from both ends so as to form a restricted opening at the middle of the tube, is provided, and it must be incorporated in the pipe line. One leg of the U-tube is connected to the orifice tube near its end and the other leg to its middle point where the greater velocity at the orifice will give a reduced pressure in the pipe leading to the U-tube.

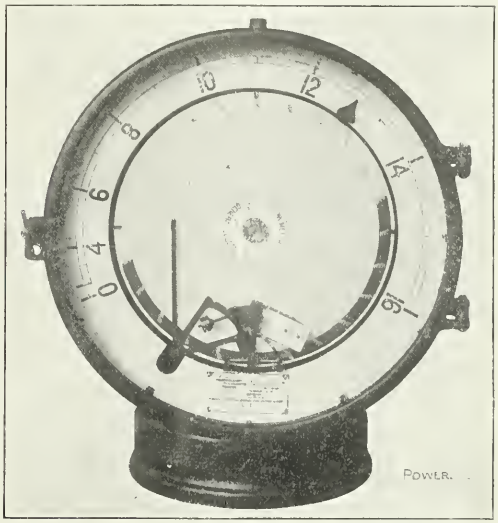


Fig. 3. Meter with Indicating Scale, Recording Chart and Integrating Dial

To meet the requirements of different classes of service and the various conditions met with, the meter can be made up in four different ways: First, as a recording or curve-drawing instrument; second, with both indicating scale and recording chart; third, with recording chart and integrating dials, and, fourth, with indicating scale, recording chart and integrating dials.

⁂

Wilkins Gage-Glass Cutter

The Wilkins gage-glass cutter is manufactured by George H. Wilkins, 57 West Lake St., Chicago, Ill. The cutting wheel is set in the end of the measuring rod at the zero mark. This rod is graduated accurately in eighths of an inch up to 8 in. The cutting wheel is held in place by a removable pin and an extra wheel is supplied with each cutter.

The cutting wheel can be pressed against the glass by means of the tongue, which is connected to a thumb lever through a link. An adjustable collar can be set at any point on the rod to form a rest or guide while cutting the glass.

⁂

Powerene, a new fuel, has recently been introduced by Dr. J. W. Rae and Reece Lockwood, of Bowling Green, O., says "Commercial Vehicle." It has not been definitely classified, but it is supposed to be secured as a byproduct of petroleum after gasoline has been extracted. It is said to be more effective as a fuel, giving greater power, that it does nor carbonize, and that it can be marketed for 3 cents per gallon.

Kilowatt Hours per Ton of Coal at Various Evaporations

By Charles H. Sammons

The following table shows the kilowatt-hours available from a ton (2240 lb.) of coal for different actual evaporation rates and for steam consumption per kilowatt-hour varying from 8 to 60 lb.

The table was compiled according to the following calculations:

Assume an actual evaporation of 4.5 lb. of water per lb. of coal; the steam consumption per kilowatt-hour being, say, 14 lb. Then the number of kilowatt-hours available from a ton of coal under these conditions is:

$$\frac{2240 \times 4.5}{14} = 720\ kw.\text{-}hr.$$

The table should be found useful in nearly every plant as it covers a wide range both as to evaporation and steam consumption of the generating sets.

WATER ACTUALLY EVAPORATED LB. PER LB OF COAL

Steam Consumption per Kw.-Hr of Engine in Lb.	4	4½	5	5½	6	6½	7	7½	8	8½	9	9½	10	10½	11
60	149 33	168 00	186 66	205 33	224 00	242.66	261.33	280.00	298 66	317.33	336 00	354 66	373.33	392.00	410 66
59	151 85	170 84	189 65	208 46	227 27	246 08	264 89	283.70	303 72	322 71	340 16	360 67	379.66	398 64	417 62
58	154.48	173.79	193 10	212 41	231 72	251 03	270.34	289 65	308 96	328.27	347 58	366 89	386 2	405.51	424 82
57	157 19	176 84	196 49	216 14	234 03	255.43	275.08	294 73	314 38	334 03	353.68	373 33	392 98	412.63	432 28
56	160 00	180.00	200 00	220 00	240 00	260 00	280 00	300.00	320.00	340 00	360.00	380.00	400.00	420 00	440.00
55	162 90	183.27	203 63	224 00	244 36	264 72	285 09	305 45	325.81	346 18	366.54	386.9	407 27	427 63	448 00
54	165 92	186 66	207 4	228 14	248 88	269.62	290.37	311 11	331.85	352 59	373.33	394 07	414 81	435.55	456 29
53	169 05	190.18	211.32	232 45	253 58	274 71	295.84	316 98	338.11	359 24	380.37	401.5	422 64	443 77	464 9
52	172 3	193 84	215 38	236.92	258 46	280 00	301.53	323 07	344 61	366.15	387.69	409 23	430 76	452.30	473 84
51	175.68	197.64	219 67	241.56	263.52	285 49	307.45	329.01	351.37	373.33	395 29	417.25	439.21	461 17	483 13
50	179 2	201 6	224 00	246.4	268 8	291 2	313 6	336 00	358 4	380 8	403 2	425 6	448.00	470 4	492 8
49	182 85	205.71	228 57	251 42	274 28	297 14	320 00	342 85	365 71	388 57	411 42	434 28	457.14	480.00	502 86
48	186 66	210.00	233.33	256 66	280 00	303.33	326.66	350.00	373.33	396.66	420 00	443 33	466.66	490 00	513 33
47	190.63	214 46	238 29	262 12	285 93	309 78	333 61	357 44	381 27	405 1	428 93	452 76	476.59	500 42	524 25
46	194 78	219.13	243.47	267 82	292 17	316.52	340 86	365 21	389 56	413.91	438 26	462.6	486.95	511 3	535 65
45	199 11	224.00	248 88	273 77	298 66	323.55	347.11	373 33	398 22	423 11	448.00	472.88	497.77	522 66	547 55
44	203.63	229.09	254 54	280 00	305 45	330 9	356 36	381.81	407.27	432 72	458 18	483 63	509.09	534 54	560.00
43	208 37	234 41	260 46	286 51	312 55	337.2	364 65	390.69	416 74	442.79	468.83	494 88	520.93	546.97	573.02
42	213.33	240.00	266 66	293 33	320 00	346.66	373.33	400.00	426 66	453.33	480.00	506.66	533.33	560.00	586.66
41	218.53	245.85	273.17	300.48	327 8	355.12	382 43	409 75	437 07	464.34	491.7	519 02	546.39	573 65	600 97
40	224 00	252 00	280.00	308 00	336 00	364.00	392 00	420.00	448.00	476.00	504 00	532.00	560 00	588 00	616 00
39	229.74	258 46	287 17	315 89	344 61	373 33	402.05	430.76	459 48	488 2	516 92	546 64	574 35	603.07	631 78
38	235 78	265.26	294.73	324 21	353 68	383 15	412 63	442.11	471 57	501 05	530.52	560 00	589 47	618 94	648 42
37	242 16	272 43	302 7	332 97	363 24	393 51	423 78	454.05	484 32	514 59	544 86	575 13	605 4	635.67	665 94
36	248.88	280.00	311 11	342 22	373.33	405.00	435 55	466 66	497 77	528.88	560 00	591 11	622 22	653.33	684 44
35	256 00	288 00	320 00	352 00	384 00	416 00	448 00	480 00	512 00	544 00	576 00	608 00	640 00	672 00	704 00
34	263 52	296 47	329 41	362 35	395 29	428 23	461.17	494 11	527 05	560.00	592.94	625 88	658 82	691 76	724 7
33	271 51	305 45	339 39	373.33	407 27	441.21	475.15	509.09	543 03	576 96	610 9	644 84	678 78	712 72	746.66
32	280 00	315 00	350 00	385 00	420 00	455 00	490.00	525 00	560 00	595.00	630.00	665 00	700.00	735 00	770.00
31	289 03	325 16	361 25	397 41	433 54	476 12	505 8	541.93	578 06	614 19	650.32	686 45	722 58	758 70	794 83
30	298 66	336 00	373 33	410 66	448 00	485 33	522.66	560.00	597.33	634.33	672 00	709.33	746 66	784.00	821 33
29	308.95	347 58	386.2	424 82	463 44	502 06	540 68	579.31	617.93	656.55	695.17	733.79	772 41	811 03	849 65
28	320.00	360 00	400 00	440 00	480 00	520 00	560.00	600 00	640.00	680.00	720 00	760 00	800 00	840 00	880.00
27	331.85	373.33	414 81	456.29	497 77	539 25	580 74	622.22	663 70	705.18	746.66	788 14	829 62	871 11	912 59
26	344 61	387 69	430 76	473 84	512 92	560 00	603 07	646 15	689 23	732.3	775.38	818 46	861 53	904 61	947 69
25	358.40	403.2	448 00	492 8	537 6	582.4	627 2	672 00	716 8	761.6	806.4	851 2	896.00	940.8	985.6
24	373 33	420.00	466.66	513 33	560.00	606.66	653.33	700 00	746 66	793.33	840.00	886 66	933.33	980 00	1026 66
23	389.56	433.91	486 95	535 65	584.34	633 04	681 73	730.43	779 13	827 82	876.52	920 86	973.91	1023 6	1071.3
22	407 27	458.18	509 09	560 45	610 9	661.81	708 13	763 63	814.54	863 45	916.36	967 27	1018.18	1069 09	1120 00
21	426.95	480.00	533.33	586 66	640.00	693 33	746.66	800 00	853 33	906 66	960.00	1013 33	1066 66	1120 00	1173 33
20	448.00	504.00	560.00	616 00	672 00	728.00	784.00	840 00	896 00	952.00	1008 00	1064.00	1120 00	1176 00	1232 00
19	471.58	530.52	589 47	648 42	707 36	766 31	825.26	884 21	943 15	1002 1	1061 05	1120.00	1178 94	1232.06	1296 84
18	495 78	560 00	623.33	684.44	746.66	808 88	871 11	933 33	995.55	1067 77	1120 00	1182 22	1244 44	1306.66	1363 33
17	527.05	592 94	658 82	724 7	790 58	856 47	922.35	988 23	1054 11	1120 00	1185 88	1251.76	1317 64	1383.52	1448 23
16	560.00	630 00	700 00	770 00	840 00	910 00	980.00	1050 00	1120 00	1190 00	1260 00	1330.00	1400 00	1470 00	1540.00
15	597.33	672 00	746 66	821 33	896 00	970.66	1045.00	1120 00	1194.66	1266.66	1344 00	1418.66	1493 33	1568 00	1642 66
14	640.00	720 00	800.00	880 00	960 00	1040.00	1120.00	1200 00	1280 00	1360.00	1440.00	1520.00	1600 00	1680.00	1760 00
13	689 23	775.38	861 53	947 69	1033 84	1120.00	1206.15	1292.3	1378.46	1464.61	1550.76	1636.92	1723 07	1809.23	1895.38
12	746 67	840.00	933 33	1026 66	1120 00	1213.33	1306 66	1400 00	1493.33	1586.66	1680 00	1773 33	1866.66	1960.00	2053.33
11	814 6	916 36	1018 18	1120 00	1221 81	1323 63	1425 45	1527 27	1629 09	1730.9	1832 72	1934.54	2036.36	2138.18	2240 00
10	896.00	1008 00	1120.00	1232 00	1344 00	1456.00	1568.00	1680 00	1792 00	1904 00	2016.00	2128 00	2240.00	2352 00	2464 00
9	995.57	1120 00	1244 44	1368 88	1493 33	1617 77	1742.22	1866.66	1991 11	2115 55	2240 00	2364 44	2488.88	2513 33	2737 77
8	1120 00	1260 00	1400 00	1540 00	1680 00	1820 00	1960.00	2100 00	2240.00	2380 00	2520 00	2660 00	2800 00	2940.00	3080 00

Table showing kw.-hr. per ton (2240 lb.) of coal. For different actual evaporations of water per lb. coal and various steam consumptions per kw. of engine.

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The recent decision of the Supreme Court of the United States in the Chandler-Dunbar case is regarded by Senator Burton, of Ohio, as of the utmost importance because of the sweeping extent to which it upholds government ownership and control of water-power and navigable rivers, and at his request the decision is being printed as a public document. The court held that owners of the river banks or river bed have no ownership of the water-power as against the government seeking to improve a river for navigation. Senator Burton laid particular stress upon that part of the decision which says that the government need not let the water-power go to waste but may use it or lease it to private individuals or concerns. This opinion of the court is evidently a direct answer to arguments recently advanced to the effect that after improving a river or stream for navigable purposes the government could not control the water-power incidentally created but must let it revert to the owners of the abutting property.—"Electrical World."

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A reservoir of 400 acres is to be constructed by means of two embankments running from an island to the mainland. The reservoir is to be further subdivided into an upper and lower tank by another embankment. The assumptions for operation are as follows: When the water in the sea is higher than in the lower reservoir or tank, it will flow in through turbines, the flow starting some time after high tide and stopping after the beginning of low tide. If the water in the sea be lower than in this tank, then through sluices it is to flow into the sea. In the upper reservoir, when the sea is higher than the tank, it will be filled through sluices, and when lower the water will flow off through turbines. A uniform tidal amplitude of 3 meters is counted upon and a difference of level of 1½ m. between the sea and the tank actually in operation. The cost of producing electricity by this means is estimated at 20 to 25 mills per kw.-hr. No necessary expense for accumulators is expected, and the cost of construction is about $1,000,000.—"Canadian Engineer."

ELECTRICAL DEPARTMENT

Primer of Electricity

By Cecil P. Poole

Wave-Connected Armature Windings

Wave-connected armature windings have two peculiarities, aside from the "throw" or spread of the coil terminals, which distinguish them from lap windings, and these are important advantages. One is that any even number of paths through a winding, up to the number of field-magnet poles, may be obtained; the other is that the conductors in each path through the winding are subjected to the influence of every pole on the field magnet. (In a simple lap winding the number of paths is necessarily equal to the number of field-magnet poles and the conductors in each path are influenced by only two of the field-magnet poles at one time, no matter how many there may be.)

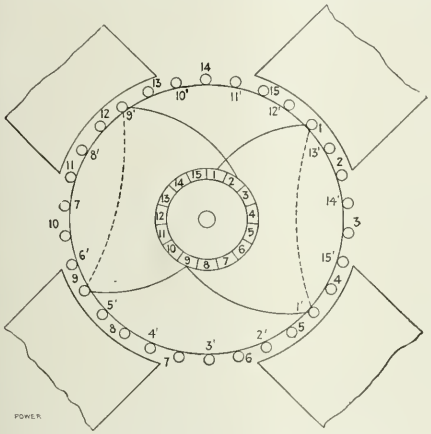

Fig. 176. Long-Pitch Wave Connection

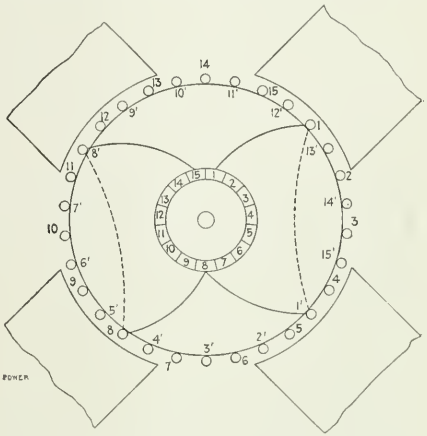

Fig. 177. Short-Pitch Wave Connection

The number of paths through a wave winding is determined by the number of coils in the winding and the distance apart of the terminals of each coil at the commutator; the latter is called the commutator "pitch," and is reckoned in commutator bars. For example, in Fig. 177, the right-hand terminal of each coil is connected to the commutator seven bars distant from the left-hand terminal; the commutator pitch in this case, therefore, is 7.

For all machines except those having half as many armature paths as there are field-magnet poles, or an equal number of both, there is only one possible commutator pitch for a wave winding having a given number of coils and paths; for machines in which the number of paths equals the number of poles or one-half that number, there are two possible commutator pitches for each combination of coils, poles and paths. These are commonly called "short pitch" and "long pitch," because the terminals of each coil are connected to the commutator farther apart in one case than in the other. Figs. 176 and 177 illustrate these statements; both diagrams show a pair of coils of a 15-coil, two-path winding having equal spread or core pitch but different commutator pitches. In Fig. 176 the coils are connected with long pitch and in Fig. 177 with short pitch; the pitch in the former diagram is 8 and in the latter it is 7.

The short-pitch connection is preferable in all cases, because it results in fewer crossings between the leads from the winding to the commutator. As Fig. 176 shows, the right-hand terminal of the second coil in each series of two crosses the left-hand terminal of its mate when the long-pitch connection is used; coils 1 and 9 form the series pair shown here. In Fig. 177, this crossing does not occur. Coils 1 and 8 form a series pair, the short-pitch connection causing coil 1 to be connected to coil 8 instead of coil 9 as in Fig. 176, and the right-hand lead of coil 8 does not cross the lead of coil 1.

The short-pitch connection gives a left-handed progression in the winding and the commutator sequence. The progression is reckoned by neighboring coils and commutator bars, as in the case of lap-connected windings, but the path passes through two coils in series (in a four-pole machine) before reaching the neighboring coil and bar. Reference to Fig. 178 will make this clearer. Tracing from bar 1 through coil 1,1′, it is necessary to trace on through coil 8, 8′ in order to get to the adjacent bar. This bar is No. 15 and the progression is, therefore, left-handed or counter-clockwise.

In a four-pole wave winding the progression is double, because of the fact that the path from one commutator bar to its neighbor leads through two coils in series. The progressions in Fig. 178 are as follows:

Primary progression		Secondary progression
Bar 1 through Coil 1, 1′	to	Bar 8 and through Coil 8, 8′ to
Bar 15 through Coil 15, 15′	to	Bar 7 and through Coil 7, 7′ to
Bar 14 through Coil 14, 14′	to	Bar 6 and through Coil 6, 6′ to
Bar 13 through Coil 13, 13′	to	Bar 5 and through Coil 5, 5′ to
Bar 12 through Coil 12, 12′	to	Bar 4 and through Coil 4, 4′ to
Bar 11 through Coil 11, 11′	to	Bar 3 and through Coil 3, 3′ to
Bar 10 through Coil 10, 10′	to	Bar 2 and through Coil 2, 2′ to
Bar 9 through Coil 9, 9′	to	Bar 1

Reading down the columns gives the progressions.

It will be noticed that the two paths are not equal; one passes through eight coils and the other through seven. This is objectionable because the electromotive

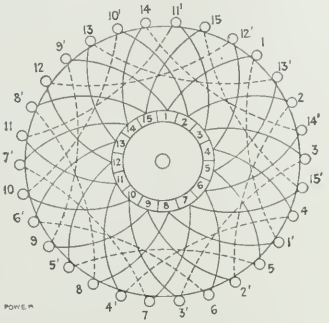

FIG. 178. FOUR-POLE TWO-PATH WINDING WITH 15 COILS

forces induced in the two paths are not quite equal, but in machines of medium and large sizes the difference is not serious because the number of coils is so large.

The general relation between the commutator pitch, number of coils, number of armature paths and number of field-magnet poles is given by the formula:

$$\frac{\text{Poles} \times \text{pitch} + \text{or} - \text{paths}}{2} = \text{number of coils}$$

This formula may be stated in rule form, thus:

I. A simple wave winding to contain a stated number of paths must contain n *coils more or less than a multiple of one-half the number of magnet poles,* n *being one-half the number of paths. (The multiplier is the commutator pitch.)*

Example: Number of poles = 8; number of coils, somewhere around 250; number of paths desired = 4. One-half the number of magnet poles is 4, and the multiples of 4 that are nearest to 250 are 248 and 252. One-half the number of paths is 2; therefore the winding may contain 2 more or less than 248 coils, or 2 more or less than 252 coils—in other words, 246, 250 or 254 coils may be used.

II. The commutator pitch of a simple wave winding is equal to twice the number of armature coils plus or minus the number of paths and divided by the number of field-magnet poles. (The division must be without a remainder.)

Example: Number of coils = 181; number of paths = 2; number of poles = 6. The commutator pitch must be either

$$\frac{2 \times 181 + 2}{6} \text{ or } \frac{2 \times 181 - 2}{6}$$

Since $2 + 181 + 2 = 363$, it is not divisible by 6 without a remainder, and the pitch must be, therefore,

$$\frac{2 \times 181 - 2}{6} = 60$$

III. The number of paths in a wave winding is equal to the difference between twice the number of coils and the product of poles × commutator pitch.

Example: Number of coils = 182; number of poles = 6; commutator pitch = 60. The number of paths through the winding is

$$(2 \times 182) - (6 \times 60) = 4$$

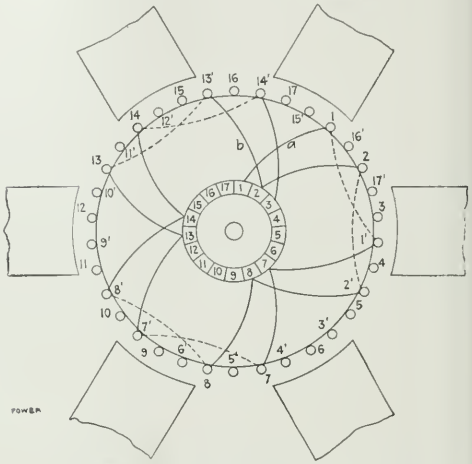

FIG. 179. MAXIMUM CROSSING, DUE TO USING THE SMALLER AVAILABLE NUMBER OF COILS

IV. A wave winding containing a number of coils exactly divisible by one-half the number of field-magnet poles will contain as many paths as there are magnet poles.

Example: A four-pole machine has 30 armature coils and the commutator pitch is 14. According to Rule III the number of paths is

$$(2 \times 30) - (4 \times 14) = 4$$

Almost all wave-connected windings used in this country are of the two-path kind and are put chiefly on machines of small and medium sizes. As the average reader

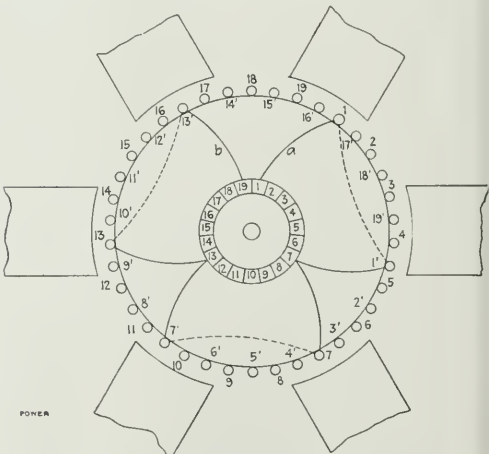

FIG. 180. MINIMUM CROSSING, DUE TO USING THE LARGER AVAILABLE NUMBER OF COILS

f this series will have to deal largely with machines of his class it may be useful to have Rules I and II modified to apply to such machines; thus:

I-a. A two-path wave winding must contain one coil more or less than an exact multiple of one-half the number of field-magnet poles.

II-a. The commutator pitch of a two-path wave winding is equal to twice the number of coils plus or minus 2, divided by the number of field-magnet poles.

Consideration of Rules I and I-a will show that there are two numbers of coils that can be used for each combination of other features. For example, a six-pole machine could have a two-path winding with either 149 or 151 coils, with a commutator pitch of 50; or a winding of either 161 or 163 coils with a commutator pitch of 54, and so on. This is due to the "plus or minus" feature of the rule—"one coil more or less" than a certain number, which number is the product of poles × commutator pitch. It is better to use the larger of the two values, because there are fewer crossings of armature leads and the neighboring leads of each set of series coils do not cross each other.

This principle is illustrated by Figs. 179 and 180. The former is a 17-coil winding and the latter a 19-coil winding for a six-pole machine, the pitch being six in both cases. The 17-coil winding contains one coil *less* and the 19-coil winding one coil *more* than an exact multiple (18) of one-half the number of magnet poles In the former, the starting lead *a* of coil 1 is crossed by the lead *b* of coil 13; the three coils 1, 7 and 13 forming a series set. In Fig. 180, where the coils 1, 7 and 13 also form a series set, the leads of coils 1 and 13 do not cross one another.

CORRESPONDENCE

Novel Transformer Connections

A short time ago it became necessary to increase the capacity of one of our stations which distributed by a three-phase, 2300-volt system. The only machine immediately available was a 100-kw., 1100-volt, two-phase, belt-driven alternator. By the use of three stock transformers, connected as shown in Fig. 1, however, we were enabled to parallel this machine with the other generators. This was accomplished as follows:

The alternator had two separate windings brought out to four taps, the two outside ones of which were connected together, forming a two-phase, three-wire system. The transformers M and N were of 50 kv.-a. each and had two primary coils to adapt them to either 1100 or 2200 volts. The primary coils were connected in series as for 2200 volts and the center taps were brought out through the case.

Connections were made to the generator, see Fig. 1, so that the right half of transformer M got 1100 volts between A_1 and A_2 and the left half of transformer N, 1100 volts between B_1 and B_2. This set up an auto-transformer effect, inducing 1100 volts across the left half of M and the right half of N; that is, the total voltage across the outside terminals of both transformers M and N was 2200 volts.

Considering only the terminals CD and EF of the transformer, this made practically a two-phase, 2200-volt circuit. The connection from E to the middle point of transformer M converted this to a three-phase system, with phases across CF, DF and CD. This, however, gave a poor balance, so one-half of the secondary coil of M was connected in circuit as shown, both transformers being 440-220 volts on the secondary side. In addition, a

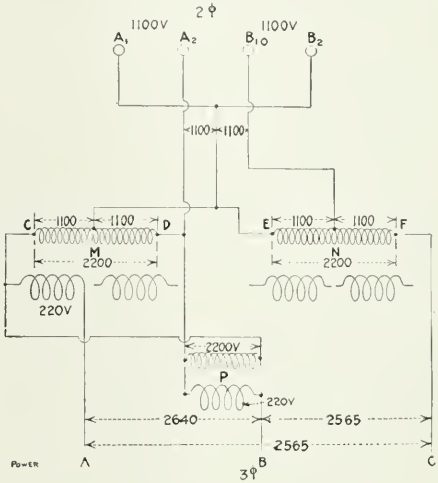

Fig. 1. Transformer Connections

5-kv.-a. transformer P was placed across CD and the secondary was connected in series with B.

The voltage between B and C, also A and C is

$$\sqrt{2200^2 + (1100 + 220)^2} = 2565$$

as represented in the vector diagram, Fig. 2.

The voltage across A and B is

$$2200 + 220 + 220 = 2640$$

as is also shown in the diagram.

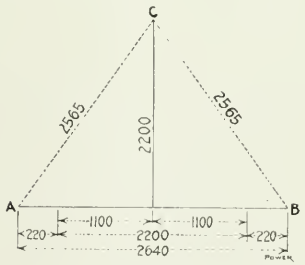

Fig. 2. Graphic Representation of Voltages

By cutting down the generator voltage by means of the field rheostat from 1100 to 1000 volts, the voltage across AB was reduced to 2400 and across both AC and BC to 2330. The remainder of the secondary coils were taped and were not used.

Earl R. Filkins.

Dixon, Ill.

GAS POWER DEPARTMENT

Make-and-Break Igniters

By Earl Paget

The make-and-break ignition system is usually considered the simplest method of gas-engine ignition. There are, however, many puzzling peculiarities found in connection with its operation, especially to the novice.

A few of these will be taken up and explained briefly, although it is first necessary to understand the operation of the igniter. This system consists essentially of (1) a source of electric current; (2) a pair of electrodes, one movable and one stationary; (3) a body-piece in which to mount the electrodes; and (4) a tripping and timing mechanism.

Operation of Igniter

The source of current is usually either a number of dry cells, a magneto, a storage battery or a combination of magneto and battery. From three to five amperes at

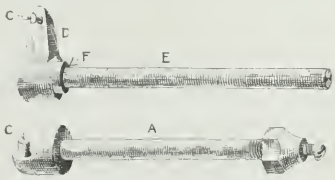

Fig. 1. Stationary and Movable Igniter

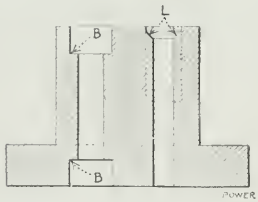

Fig. 2. Body Piece

six or eight volts is sufficient. Any more than this only burns the points needlessly. Fig. 1 represents a pair of electrodes in which *A* is the stationary and *E* the movable members. They project into the cylinder and the points *CC'* are brought together and separated quickly by the tripping mechanism at the proper instant, causing ignition of the gas by the resultant arc.

The stationary electrode is insulated from the body-piece with mica, or some other heat-resisting nonconductor. The positive wire is usually connected to this electrode and the negative wire is grounded to the engine frame, but not necessarily, as either way will do.

The movable electrode consists of an arm *D* and a stem *E*, Fig. 1. The arm *D* carries the point *C*, and the stem passes through the body and the actuating mechanism is attached to the outer end. A shoulder *F* seats against the body-piece and right here is where trouble often occurs as will be explained later.

The body-piece is made the most convenient shape to receive the electrodes and hold the tripping and timing mechanism. The hole through which the stem of the movable electrode passes is made of such size as to make a running fit with the stem. The hole for the insulated electrode is made somewhat larger than the electrode stem and is counterbored at each end to receive the insulating washers, as shown at *BB*, Fig. 2.

Fig. 3 shows the tripping and timing mechanism of one form of this class of igniter. Nearly all others of this class work similarly. The arm *A*, Fig. 3, is fastened rigidly to the end of the movable electrode stem with the half-round taper pin at *B*. The arm *C* does not fasten to the movable stem, but has an opening which fits over the stem behind *A*. The edge of *C* is bent over arm *A* on top and also under it, and rests on the pin *H* at the bottom, leaving a lip at *E* to be engaged by the finger *F*. A spring *D* fits on a pin in the lower part of *C* and into a hole in *A*; another spring *D* also fits over a pin in the

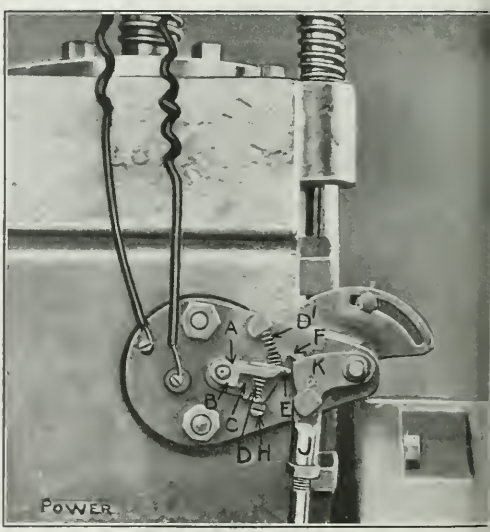

Fig. 3. Ignition System Outside the Cylinder

upper part of *C* and into a hole in a pin, which is screwed into the body of the igniter. The operation is as follows: The rod *J* is given an oscillating motion from an eccentric on the camshaft, and the finger engages the lip *E*, raising both the arms *A* and *C* until the points are brought together in the cylinder or valve chamber, after which there is no further upward movement of *A*. The arm *C* continues upward, however, compressing the

springs D and D', until the instant of ignition, when the finger slips off the lip E and allows the springs to force C onto A, thereby opening the circuit quickly and causing the arc between the points on the inside of the cylinder. A spring inside at K allows the finger to push back and pass E on the return stroke, after which the cycle is repeated.

Igniter Troubles

The troubles with this class of igniter may be either mechanical or electrical. The most common is the sticking of the movable electrode in the body ot the igniter. To the novice this may appear to be due to insufficient lubrication, but it is usually caused by the stem being covered with carbon. This is because the shoulder does not fit tightly against its seat, and allows the burning gases to leak past the shoulder and burn the oil on the stem, causing it to stick If this shoulder is ground to a tight fit with oil and emery the chances are that no more trouble will be experienced in this line. The shoulder can be ground by fastening the igniter in a vise and turning the stem with a breast drill or, better still, chuck the end of the stem in a lathe or drill press, hold the body and let the machine turn the stem.

The insulated electrode will have to be removed, so that the stem can turn all the way around. It is best not to try to change stems at all. When the point becomes too short on this electrode, take it out and put in a new point. If it is inconvenient to have the engine out of commission long enough, it will pay to have an extra igniter on hand.

In order to prepare the body for a new electrode it is necessary to drill out and bush the hole square to fit the new shoulder. In drilling out the hole for the bushing, a drill of about the same diameter as the outer diameter of the shoulder should be used. One inch is deep enough to drill. After the hole is drilled a brass or cast-iron plug is turned to a snug driving fit, driven in and cut off flush with the body. The hole is then drilled through this plug from the opposite end with a drill of the same size as the original hole. This makes a neat job, as shown by the dotted lines in L, Fig. 2. The new electrode can now be ground to this and the igniter is as good as new.

Another source of trouble is in the contact points. Some builders use points of such small diameter that they soon burn off so short that the tripping mechanism cannot bring them together properly. This necessitates taking out the old points and putting in new ones. While some builders use platinum for these points, cold-rolled steel will answer well, excepting that it will not last quite as long. It has been the writer's practice in pointing the movable electrode to turn ⅜-in. round cold-rolled steel down on one end to fit the hole in the electrode, drive it through to the shoulder and head it over on the other side. For the stationary electrode, a piece of the same kind of material ¾ in. diameter by ¾ in. long is drilled and tapped axially and the stem is screwed into it. All that is required to renew the points then is to loosen the nut on the outer end and turn this electrode so that the point on the movable electrode finds a new contact on the ¾-in. disk.

The same material should be used for the disk that is used for the point because if contacts of dissimilar metals are used, a deposit from one seems to form on the other and this will cause poor contact and a weak spark will result.

Another trouble that sometimes arises and is hard to locate is caused by a point working loose in its socket. It may be hardly loose enough to detect, but the joint tends to soot over and poor contact results. The points must be kept tight.

Providing the source of current is not to be questioned, the electrical faults may be either grounding of the insulated side or poor contact. The following simple test will usually identify the trouble. With the igniter tripped and with current turned on, disconnect the wire from the insulated electrode. Touch it firmly to the body of the igniter or any convenient part of the engine frame and let it spring off quickly. If a good spark results the source of current and the conductors to the igniter are all right.

Next touch the wire to the insulated electrode. If a spark occurs here this electrode is grounded. If none occurs it is as it should be. Now push up the tripping mechanism until the points are together and repeat the operation on the insulated electrode. If a good spark occurs the points are clear but if no spark or a very weak one occurs, the trouble is in the points.

Lubricating troubles are seldom experienced with the igniter stems on four-stroke-cycle engines. Some trouble is experienced at times, however, with the igniters on two-stroke-cycle engines. This can be traced to the fact that there is a sort of endwise check-valve action to the stem on the four-stroke-cycle machine that is absent on the two-stroke-cycle engine. That is, the shoulder is pushed against its seat during the compression, explosion and exhaust strokes and is pulled away during the suction stroke of the four-stroke-cycle engine, while the shoulder is held against the seat at all times in the two-stroke-cycle engine. In the latter case it is difficult to get oil to the shoulder and the inner end of the stem without flooding which usually causes trouble through the formation of carbon.

The writer has had favorable results by oiling the stems only when they are taken out and cleaned after a run of 168 to 240 hr. and using then only an amount that could be rubbed on with the finger. Some of the late engines have the igniters water-jacketed, which practice tends to keep down carbon trouble.

❖

Anyone who works with gas engines, coke ovens or gasoline apparatus that requires vapors rich in hydrogen, has been at one time or another confronted with preignition difficulties. To these the method of Dugald Clerk comes as a most timely help. His procedure is to substitute for the air in the gaseous charge, some of the cooled exhaust products. Thus the inert gas which is added reduces all chance of inflammability by greatly diminishing the oxygen yet without diminishing to any appreciable degree the total power of the charge.

Another discovery of Dr. Clerk while on the Gaseous Explosion Committee of the British Association, was that the greater part of the heat was lost during the expansion stroke which occurs at the crest of the temperature wave. This he proved to be not a surface loss, but a loss by radiation.

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According to the United States Geological Survey, the quantity of coal used for coke making in the United States in 1912 was 65,485,801 short tons. The coke produced from this coal amounted to 43,916,834 short tons, valued at $111,523,336, besides large quantities of gas, tar, benzol, ammonia, etc., as byproducts from the 11,048,489 tons of coke produced in byproduct ovens.

REFRIGERATION DEPARTMENT

Capacity of Ammonia Compressors

By R. L. Mossman

The accompanying sketches show some diagrams taken from ammonia compressors. Fig. 1 is a diagram taken from a double-acting, wet-compression machine with weak suction-valve springs. As will be seen, there is no projection below the suction line, the weak springs causing the valves to leak slightly. The cylinder diameter is 19 in.; the stroke, 36 in.; the speed, 40 r.p.m.; head pressure, 190 lb.; back pressure, 17 lb., and the spring 100.

Fig. 2 shows the result of running a compressor at too high piston speed for the size of the suction valves. The machine was running at 120 r.p.m., single acting, against a head pressure of 153 lb., and suction of 20 lb. gage.

The apparent tonnage of the machine, while running at 120 r.p.m., is figured as follows: Area of cylinder, 78.54 sq.in.; capacity in cubic inches, $78.54 \times 18 =$

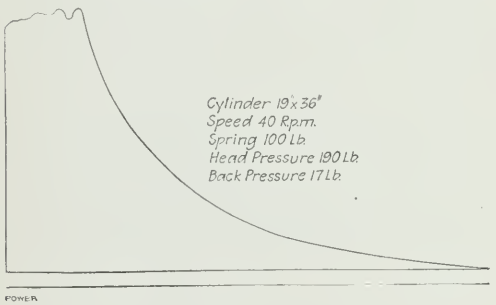

Fig. 1. Weak Suction-Valve Spring

1413.72 cu.in.; cubic feet displacement per minute at 100 per cent. efficiency,

$$\frac{1413.72 \times 120}{1728} = 98 \; cu.ft.$$

As the diagram shows a reëxpansion loss of 8 per cent., the amount of gas that can enter the cylinder is 92 per cent. of its volume.

The loss due to the low suction pressure in the cylinder, caused by the high speed, is as follows: The suction pressure shown by the gage is 20 lb. or 34.7 lb. abs. The pressure in the cylinder, as shown by the diagram, is 23.7 lb. abs. Therefore,

$$23.7 \div 34.7 = 68.3 \; per \; cent.$$

This means that due to the drop in suction pressure, each cubic foot of gas in the compressor represents only 68.3 per cent. of ammonia by weight that there would have been had the gage suction pressure been realized in the cylinder. The apparent efficiency is

$$0.92 \times 0.683 \times 100 = 62.8 \; per \; cent.$$

The actual displacement then equals

$$98 \times 0.628 = 61.54 \; cu.ft. \; per \; min.$$

The cubic feet of gas required per minute, as shown in Table 1, at 153 lb. head pressure and 20 lb. suction pressure, is 3.34 and

$$\frac{61.54}{3.34} = 18.4 \; tons$$

Using Table 2, which gives the refrigerating effect of 1 cu.ft. of gas in B.t.u. at different pressures, the tonnage is

$$\frac{59 \times 61.5}{200} = 18.14$$

When card *B* was taken the machine had been slowed down to 85 r.p.m. The head pressure was 153 lb., the suction pressure 25 lb. gage, or 39.7 lb. abs., and the suction pressure by card 20 lb. gage, or 34.7 lb. abs. The cylinder displacement per minute at 100 per cent. efficiency is

$$\frac{1413.72 \times 85}{1728} = 69.5 \; cu.ft.$$

Deducting the loss of 5 per cent., due to reëxpansion, leaves 95 per cent. of the cylinder volume. The suction pressure by card being 34.7 lb. abs. and by gage 39.7 lb. abs. reduces the density of the vapor to 87.4 per cent.,

TABLE 1. CU.FT. GAS REQUIRED PER MIN. TO PRODUCE 1 TON REFRIGERATION IN 24 HR. AT DIFFERENT PRESSURES

Temp. of Gas, Deg. F.	Suction Press. Gage	Temp. of Gas, Deg. F. 65	70	75	80	85	90	95	100	105
		Gage Press. 103	115	127	139	153	168	184	200	218
—27	1	7 22	7.3	7 37	7 46	7 54	7 62	7.7	7.79	7 88
—20	4	5.84	5 9	5 96	6 03	6.09	6 16	6 23	6 3	6.43
—15	6	5.35	5.4	5 46	5.52	5 58	5 64	5 7	5.77	5 83
—10	9	4 66	4.73	4 76	4 81	4 86	4 91	4 97	5 05	5.08
—5	13	4 09	4 12	4 17	4 21	4 25	4 3	4.35	4 4	4 44
0	16	3.59	3 63	3 66	3 7	3 74	3 78	3.83	3 87	3 91
5	20	3.20	3 24	3 27	3 3	3 34	3 38	3 41	3 45	3 49
10	24	2 87	2 9	2 93	2 96	2 99	3 02	3 06	3 09	3 12
15	28	2 59	2 61	2 65	2 68	2 71	2 73	2 76	2 8	2 82
20	33	2 31	2 34	2.36	2 38	2 41	2 44	2 46	2.49	2 51

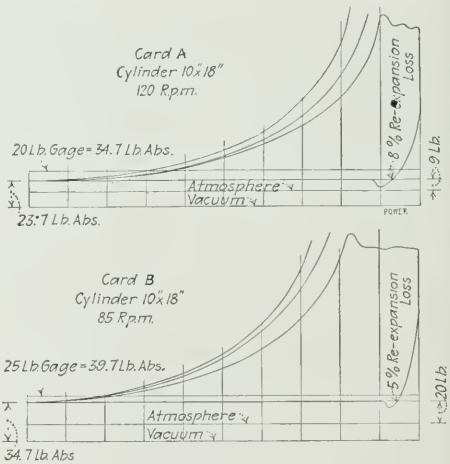

Fig. 2. Result of High Speed for Size of Suction Valve

due to the difference in suction pressures. The apparent efficiency is then

$$0.95 \times 0.874 \times 100 = 83 \text{ per cent.}$$

The actual displacement is

$$83 \times 69.5 = 57.7 \text{ cu.ft.}$$

According to Table 1 this would give

$$\frac{57.7}{2.92} = 19.76 \text{ tons}$$

To be able to compare the two figures of apparent tonnage obtained from cards A and B of Fig. 2 it is necessary to equalize the suction pressures. The compressor working at 120 r.p.m. and 25 lb. instead of 20 lb. back pressure would probably show an apparent tonnage of

$$\frac{18.4 \times 3.34}{2.97} = 20.7 \text{ tons}$$

TABLE 2. REFRIGERATING EFFECT OF ONE CU.FT OF AMMONIA GAS AT DIFFERENT PRESSURES

Temp of Gas, Deg. F	Suction Press., Gage	Temp. of Liquid in Deg. F Condenser Press. Gage 65	70	75	80	85	90	95	100	105
		103	115	127	139	153	168	184	200	218
— 27	1	27.3	27.01	26.73	26.44	26.16	25.87	25.59	25.30	25.02
— 20	4	33.74	33.40	33.04	32.70	32.34	31.99	31.64	31.30	30.94
— 15	6	36.36	36.48	36.10	35.72	35.34	34.96	34.58	34.20	33.82
— 10	9	42.28	41.84	41.41	40.97	40.54	40.10	39.67	39.23	38.8
— 5	13	48.31	47.81	47.32	46.82	46.33	45.83	45.34	44.84	44.35
0	16	54.88	54.32	53.76	53.20	52.64	52.08	51.52	50.96	50.4
5	20	61.50	60.87	60.25	59.62	59.00	58.37	57.75	57.12	56.5
10	24	68.66	67.97	67.27	66.58	65.88	65.19	64.49	63.80	63.1
15	28	75.88	75.12	74.35	73.59	72.82	72.06	71.29	70.53	69.76
20	33	85.15	84.30	83.44	82.59	81.73	80.88	80.02	79.17	78.31
25	39	95.50	94.54	93.59	92.63	91.68	90.72	89.97	88.81	87.86

The increase in speed of the machine from 85 to 120 r.p.m. increased the apparent tonnage only from 19.76 to 20.7, or 0.94 ton. In these calculations the effect of superheating in the compressor has not been taken into consideration, and this factor, depending somewhat on the design and operation of the machine, would reduce the actual refrigerating effect to from 85 to 90 per cent. of the apparent values obtained.

It is well when speeding up a compressor to apply the indicator and see that the suction pressure in the cylinder is not reduced too much below that shown by the gage.

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Figuring Power for Refrigerating Plants

By Samuel Sydney

Before reasonably accurate simple computations regarding the power required for any given ice-making or refrigerating duty can be made it is essential that a correct basis for determining the amount of heat removal and a fixed unit of refrigerating capacity be known. Concerning the heat removal not only must the sensible and latent heat to be removed from the material involved be known, but also the various amounts of heat leakage.

If it is known that the goods placed in a room for cooling or the liquid placed in a can for freezing are at a certain temperature and must be reduced to another temperature, it is essential to have a correct basic rating: first for the sensible heat of the material; second for the latent heat, if its state is changed by the cooling, as in freezing water, and third for the quantity of heat that will flow from other near-by bodies to the article being cooled or frozen.

To measure sensible heat there are various temperature-measuring instruments, sufficiently accurate for nearly all purposes, so that this factor may be passed over. All substances also absorb heat at constant temperature when they change their state from solid to liquid or from liquid to gas, and this amount of heat is again made latent when they change back to their original state. To forget to allow for this latent heat might prove a costly error. Just what is the correct latent heat of the most common and most frequently used substance, water, has not yet been fully determined. When water changes its state from liquid to vapor it is known that about 970 B.t.u. for each pound must be added from and at the temperature of 212 deg. F. before the sensible heat will increase and that when recondensed to water, this vapor will surrender the 970 B.t.u. before its sensible heat falls below 212 deg. F. If frozen water, or ice, is heated its temperature rises readily to 32 deg. F., but it rises no higher on the thermometric scale until about 142 B.t.u. according to some, and 144 B.t.u. according to others, have been added per pound.

While a difference of two heat units per pound would not figure up very much on a small machine, it would amount to considerable in figuring on such a machine as the 1000-ton compressor installed by the Quincy Market Cold Storage & Warehouse Co., Boston, Mass., in 1912, or the still larger machine, said to be of 1200 tons daily refrigerating capacity, now being built in Germany for an ice-manufacturing concern in Buenos Aires, Argentine Republic. Either of these machines would be capable of producing at least 500 tons of ice daily or 1,000,000 lb. A difference of two units per pound, therefore, would mean 2,000,000 B.t.u., which is equivalent to nearly eight tons of refrigerating capacity per day.

Far greater and much more uncertain of calculation is the extra heat that must be removed because of heat leakage. If the exact coefficients of heat leakage for the various types and kinds of wall construction were known there would be little difficulty. As it is we are confronted with a mass of estimates and with results of tests made by interested parties on particular kinds of construction differing in many ways from any that are met with in practical business.

It is learned from private and semiofficial tests that for some of the best known types of insulated-wall construction the coefficient is somewhere between 1 and 3 B.t.u. per sq.ft. of surface per 24 hr. per degree difference between outside and inside temperature. And even with this factor it is necessary to rely more or less upon estimate, as the difference between temperatures outside and inside is constantly varying as weather conditions change. With thick walls composed of material that offers comparatively little resistance to the passage of heat or of such faulty construction with the best material that conductors of heat remain in the walls, the coefficient of heat transmission rises to 5 and 6 or even to 10 and 12 units per sq.ft. per 24 hr. per degree difference. What this means is evident from a simple example. Given a room 30 ft. wide, 80 ft. long and 10 ft. high, there would be 7000 sq.ft. of surface. At 2 B.t.u. per sq.ft. per 24 hr. with a temperature difference of 30 deg., this would mean a heat gain of

$$7000 \times 2 \times 30 = 420{,}000 \text{ B.t.u.}$$

At 10 B.t.u. heat transmission the gain would be

$$7000 \times 10 \times 30 = 2{,}100{,}000 \text{ B.t.u.}$$

The one would mean about 1.4 tons daily refrigerating effect and the other 7.3 tons, merely for taking up heat

leakage. Then in addition the heat introduced at openings that are not air-tight when closed and that which rushes in at times of entrance and departure from the cold room, the heat radiating from the person who brings in or takes out goods, or inspects the place, and the heat radiating from lights. All these must also be considered and provided for. It is customary to make an arbitrary allowance to cover all these heat leakages. If the allowance proves too small, occasional losses on goods prove costly, as many have experienced. If the allowance is too large, there is not only the loss on extra investment but on operation of the larger plant.

In the manufacture of ice it is necessary to take up not only the latent heat per pound of water to be frozen, but also the sensible heat to be removed from the water above, and from the ice below, 32 deg. F., the heat that leaks into the can through the imperfect covers and that which leaks into the freezing tank through its insulation and from the tank surface.

Granted that the total amount of heat to be removed by refrigerating machinery for any given service has been determined closely, uncertainty again creeps in when it is desired to determine definitely just how large a machine will produce the refrigeration required.

Competent operation also enters into the question. It is not an uncommon occurrence to find refrigerating plants operated apparently at the limit of their capacity, but when taken in charge by a competent engineer who makes a few slight and inexpensive changes that the machine does from 10 to 25 per cent. more work and with actually less cost for power.

To figure the power required for an ammonia compressor it is necessary to know the temperature of the condenser water and also the quantity of water that can be used on such a condenser per minute. The type of condenser has some bearing on the case. It is necessary to know the temperature to be maintained in the refrigerator and the weight of gas that must be compressed to produce such a temperature. It is common practice to merely estimate the power required and provide accordingly. Manifestly this is not the most efficient or economical method. The rules for figuring power requirement are for the most part approximate only, as a number of factors, not usually considered, enter in to modify the result. Thus, for example, in the matter of condenser water, if one gallon per minute per ton of refrigeration per 24 hr. of 56-deg. water is used in the condenser, the resulting condenser pressure is about 150 lb. If three-fourths of a gallon of 56-deg. water is used the pressure will run up to about 190 lb. If three gallons of such water can be utilized the pressure will be only 105 lb. and the work of the compressor will be reduced between 20 and 25 per cent.

Dr. Siebel's rule for figuring the power for a compressor has probably been used more than any other and may be stated as follows:

$$P = \frac{\textit{Diff. between temp. in refr. coils and in condenser}}{\textit{Temp. in refrigerator} + 460\ (\textit{abs. temp.})} \times \textit{lat. heat of vaporization} \times \textit{weight of gas entering comp. per min.} \times 0.0234$$

The coefficient 0.0234 is obtained by dividing 778, the foot-pounds equivalent to one heat unit, by 33,000.

The weight of ammonia to be pumped per minute is found by subtracting the difference between temperatures in the condenser and refrigerator from the latent heat of vaporization at the refrigerator pressure, which gives the refrigerating effect of one pound of the refrigerant. Then the quotient obtained by dividing the total refrigerating duty expressed in thermal units by the refrigerating effect of one pound of refrigerant gives the theoretical weight of gas that must be pumped per minute.

Thus, given a case where a million British thermal units per hour are to be taken up; temperature to be maintained in chill room 20 deg. F., equal to between 10 and 15 deg. in the refrigerator coils, and liquid ammonia leaving condenser at 90 deg. From the latest ammonia tables the latent heat of vaporization at 20 deg. F. is 556; then $556 - (90 - 10) = 476$

$$\frac{1{,}000{,}000}{476 \times 60} = 35$$

the number of pounds of ammonia that must be circulated per minute to take up one million heat units per hour. Then, according to the formula,

$$P = \frac{90 - 10}{10 + 460} \times 556 \times 35 \times 0.0234 = 77.5$$

the horsepower required to operate the compressor. This does not allow for losses by friction or by superheat of the ammonia entering the compressor and hence it is customary to add from 10 to 20 per cent., or, say, an average of 15 per cent., to make up for these losses. The actual horsepower required would then be

$$77.5 + (0.15 \times 77.5) = 89.1$$

The engine driving the compressor will require about one-third more power or $89.1 \times 1\frac{1}{3} = 118.8$ *hp.*

The horsepower required for steam pumps, vacuum pumps, etc., may be figured according to formulas given in standard handbooks, but the result will be by no means always dependable, for a number of errors may creep in, due to leaks, slipping of belts, friction, imperfect valve action, etc. It is still true today, as it was ten years ago, that many pumps in actual use yield little over 50 per cent. of their theoretical capacity. The old rule of 120 lb. of steam per i.hp.-hr. for ordinary steam pumps is still not far from the amount actually consumed.

Conditions vary so greatly not only in different plants, but at different times, in the same plant, that it is exceedingly difficult to secure a short cut for figuring power requirement that would fit all cases. Temperatures of the liquid refrigerant, air or foul gases in the system, quantity of refrigerant in circulation, varying temperatures to be maintained at the same back pressure, these and other items, all effect the result.

So far as the capacity of the refrigerating machine itself is concerned, this is almost entirely proportional to the weight (not volume) of ammonia circulated and this weight depends upon the suction pressure and the cubic feet displacement of the compressor. In elaborate tests made some years ago the conclusion was reached by Professor Denton that the practical range of economical suction pressure lies between 7 lb. gage with which a temperature of zero can be maintained, and 28 lb. gage, with which temperatures above 28 deg. F. are maintained. But at 7 lb. suction pressure only about half as much ammonia by weight can be circulated as at 28 lb. back pressure. For each cubic foot of compressor displacement about one-sixth of a ton of refrigerating effect per 24 hr. can be produced at the low back pressure and about one-third of a ton at the higher back pressure.

EDITORIALS

Keokuk Hydro-Electric Power Plant

The hydro-electric station of the Mississippi River Power Co., described in this issue, will be formally dedicated on Aug. 26. Of so great public importance is this plant that President Wilson will attend the ceremonies. As will also the governors of the twenty-seven Mississippi Valley states and the entire legislatures of the three most nearly concerned states of Iowa, Illinois and Missouri.

Restrictions of space prevent proportionate treatment of the features of this gigantic development, but such as is given must be read carefully if the reader hopes to get even a glimmering conception of the magnitude of the work. While it is but slightly more difficult to write the figures representing thousands and millions than to write those representing tens and hundreds, it is well nigh impossible for ordinary mortals to appreciate the relative size or value of the quantities expressed by the former.

With over 200,000 kw. becoming available at low cost in the heart of a heretofore purely agricultural section and with good competitive transportation, facilitating the shipment of products to the big centers of distribution, the towns within one hundred or more miles of Keokuk seem destined to reap marked benefit from the erection of this plant, especially as the published policy of the power company is to reserve a large percentage of its output for sale to manufacturing enterprises. With the advent of manufacturing must come increase in population which will tend to stimulate agriculture in contiguous sections and increase both rural and urban real-estate values.

The history of the project of compelling the mightiest of the rivers in North America to do service for man extends back to 1857. In all the time since then people have constantly schemed and worked for the end that has now been attained, their efforts growing stronger and stronger as time advanced.

Ultimately, prominent men of Keokuk, Iowa, and Hamilton, Ill., organized the Keokuk & Hamilton Water Power Co., with a paid-in capital of only $2500 and having for its object the work of interesting investors, engaging engineering talent and securing the proper authority from the federal government to build the dam.

Through the activities of this company, Hugh L. Cooper, a distinguished engineer and the builder of numerous important hydraulic-power plants in this country and elsewhere, became interested and engaged in the work of securing the needed capital of twenty-odd millions, an almost Herculean task in itself, as was soon discovered. After about four years of search, during which many well nigh insurmountable difficulties were overcome, the needed funds were secured and the work of construction was started in earnest late in 1909, with Mr. Cooper personally in charge of the entire operation as chief engineer.

All of the many and unusual problems that arose during the design and construction of this unusual plant were faced and solved either by Mr. Cooper personally or by his assistants with his guidance and inspiration. Thus, the story of the realization of what had been a dream for almost three-score years, is the story of the efforts of one man.

Mr. Cooper, who is still in his forties, was born in Wisconsin and began his career as a worker on strain sheets for a bridge company. Later he built some bridges in the vicinity of Seattle, Wash. His first water-power work was done in Jamaica. Later, he built some plants in Mexico and Brazil. Then he constructed the plant at Niagara Falls, the tailrace of which is a tunnel opening under the curtain of the falls. His next plant was at McCall's Ferry, Penn., and before this was completed he began his labors on the Keokuk development.

⁂

Treatment of Employees

A system of medical inspection has been instituted by the Brooklyn Rapid Transit Co., which has much to commend it.

It seems that this company interested itself in the welfare work of its employees to the extent that it investigated the treatment of excuses offered for illness and absence by the employees in the various divisions and found that many men reported sick to get time for recreation purposes.

To meet this condition a medical-inspection bureau was established and the results of six months' working show a reduction of twenty-three per cent. in the number of days lost on account of illness as compared with the first six months in 1912.

The pleasing part of the results is that the reduction in time lost due to illness is not due to a decrease in the number of men reporting sick, but to a shortening of the time of sickness. Prior to the establishment of the system many men would contract minor illnesses and continue to work until the sickness had developed into something serious, which forced them to be absent for a week or more.

Now the men go for examination as soon as they feel slightly sick and much time and money is saved both to the individual and the company. The work is carried on by the same organization which conducts the free medical attendance in connection with the mutual-benefit association among the employees of the company.

The whole thing—system and results—illustrates the value of treating employees as men and citizens and not as mere machines or commodities. If a system of this kind should be organized in any concern, and the actions of those at the head of the system should give the employees the suspicion that there were other than mutual welfare motives back of it all, the system would do more harm than it could ever undo. Most men will respond with kindness and good will to kindly treatment and will as quickly retaliate if approached with trickery that they think aims to do them no good.

The boss of former times, who cursed like a pirate and

who thought the most effective way to get results was to make his men afraid of him, is gone. A work room, power plant or business office will not get out good work if conducted like a Sunday school, and less real work will be done if run like a whaling crew. Treat employees with kindness and discharge those shirks and fakers that will not respond. The medical-inspection system of the Brooklyn Rapid Transit Co. is a commendable step in this, the right direction.

⁂

Selecting Engineers

"The largest sums of money, the finest materials, the latest and best equipment, the most cleverly and intelligently devised methods will not be efficient unless there are men fitted by nature and training for their tasks, in the right places, at the right time, and with the right training, guidance, direction and supervision."

This statement was made in a paper on the "Scientific Selection and Assignment of Men in the Creation of an Organization," by Dr. Katherine M. H. Blackford before the last annual meeting of the Efficiency Society. It was spoken of all lines of endeavor impartially, but it could hardly have fitted more exactly had it been said specifically of the field of power-plant engineering. We wish that we might get the truth of this statement home to the owners and managers of all power plants. From time to time we have remarked how inconsistent it is to lay out large sums of money for the finest power-generating equipment and then put it under the charge of incompetents. We have said it so many times ourselves, we are glad to give it in the words of another in the hope of emphasizing it, particularly when given, as in the original of this case, as a universal fact.

We have no comments to make on the main issue of the paper quoted from as to how the best adapted workers may be selected, not by "hit-and-miss" or the "hiring-and-firing" methods, but by scientific analysis of their characters and qualifications. It is a deep subject and one destined to mean much to the material progress of our industries in the next decade.

So far as the selection of power-plant engineers and their helpers is concerned it would not seem that there should be any serious difficulty in the way. In states having license laws (may their number increase) there is the means at hand to determine the man's qualifications of knowledge and experience. Common sense and the study of mankind enable a decision as to suitability of character.

Wherein then is the difficulty? Is the supply of capable operating engineers insufficient for the demand? (Some claim they cannot get the right men.) We are not prepared to answer the above question. In some localities there may be, probably are, plenty of good men available, and in others the reverse may be true. This we know: When the remuneration paid operating engineers is more nearly commensurate with what is expected of them, as judged by comparison with other professions, there will be no lack of material. Make the field more attractive and it will not be a great while before it is crowded.

This much may be said of the situation at present. Those now engaged in this line of work are in it for the love of the work—not the love of the pecuniary return.

Power-Plant Emergencies

Power-plant operation, when everything is going smoothly, calls for just watchfulness on the part of the operator or, in other words, merely ordinary routine work. This is why so many steam plants, which are in reasonably good condition, can be operated for months by a man who is not entirely competent and who is not big enough for the position when anything of a serious nature does occur.

It is the unexpected happenings in power-plant operation that show up the ability of the men in charge and often call for quick work in making temporary repairs to maintain the service. An instance of resourcefulness in time of difficulty to minimize disastrous consequences is to be had in an experience at the Shreveport, La., power plant.

Two accidents occurred in succession: The first was the collapse of an extension of the engine room, which left the switchboard exposed to the elements, but it was protected as soon as possible by a temporary wooden inclosure. About a month later a short-circuit on the high-tension line at the switchboard ignited the temporary wooden shelter. From this the fire spread throughout the engine room, putting out of commission all but one of the four generating units, by destroying the belts driving them. All of this happened within not more than fifteen minutes.

Here was a situation to try the ingenuity of those in charge. The business section, containing over thirty-five thousand people, depended upon this plant for electrical energy, and everything was at a standstill for want of belting. The superintendent of the electrical department decided that pieces of scrap belting could be used to repair such parts of the generator belts as were not completely destroyed, and by daylight the following morning, two power circuits were in service and the lighting circuits were cut in a few hours later.

While this repair work was being done an order for belting was sent and the shipment was received six days after the fire. A new switchboard was also ordered and shipped twenty-one days from the date of the order. Inside of three months the plant which had been wrecked by the collapsing of the walls and by fire was giving regular service to its patrons.

Such occurrences as these bring out the best there is in those in charge. Although the strain and anxiety may be wearing, and many hours of hard work necessary, there is after all a satisfaction in the knowledge that the difficulties have been met and the obstacles overcome.

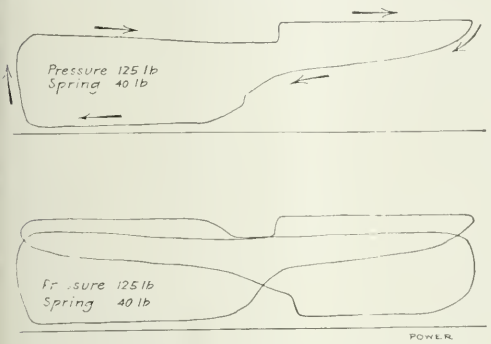
⁂

As showing how our German cousins can entertain, the account of the joint meeting of the Verein deutscher Ingenieure and the American Society of Mechanical Engineers given on a later page is interesting. These joint meetings contribute much to engineering progress as a direct consequence of the papers and discussions at the professional sessions. No doubt, those fortunate enough to attend reap the largest benefit, by seeing the foreign engineering works and meeting those of other nations engaged in kindred pursuits, but there is no measuring the number of people, engineers and others, in both nations, who indirectly profit to some extent. The good fellowship created by such meetings of the various professions has a deeper significance than many realize.

READERS WITH SOMETHING TO SAY

Diagrams from Jet-Condenser Pump

The illustrations show diagrams from the steam end of a jet-condenser pump. The single diagram was taken from the frame end and the arrows show the direction of the pencil travel. The indicator was connected to the drips. The pump was making about 80 strokes per minute and carrying a 24-in. vacuum in the condenser head.



DIAGRAMS FROM JET-CONDENSER PUMP

The diagrams show clearly the extent of the jump at the beginning of the stroke and also show the error that may be made by studying the diagram from one end alone when finding the power applied. By examining the single diagram it looks as though the larger amount of power was used at the beginning of the stroke while a study of the double diagram shows that the larger amount of power is used on the last half of the stroke.

LESTER A. FITTS.

Leominster, Mass.

Broken Pipe Fitting Damages Engine

When I arrived at the plant one morning, the night engineer reported that one of the engines was badly damaged. He said that it had been running as usual, when, without warning, the smashup occurred.

The engine was a small 9x10-in. automatic, running at 350 r.p.m. Upon examining it, I found the valve rod doubled up, the rocker-arm broken off, the eccentric rod badly bent, the oil guard smashed and the bolt holding the eccentric to the governor arm sheared off. I removed the steam-chest cover and found a small piece of an elbow that had caught endwise between the edge of the valve and the wall, preventing the valve from moving farther, causing the damage as a result.

I assume that a pipe fitter had broken a fitting, a piece of which had fallen inside the steam pipe and had been forgotten, finally working its way along to the engine with the results stated. As there had been no work done on any of these lines in the last two years, the piece had been in the line that long or longer.

Now, I know that I have often broken a fitting when I was in a hurry or when it was necessary and I have no doubt other engineers have done the same. This accident will cause me to be a little more careful in the future.

ARTHUR V. LACY.

Julietta, Ind.

Fuel Costs Reduced

The price of coal at the present time is such that engineers in charge of power plants are ever on the lookout for some new device or idea which will enable them to reduce the coal costs. The writer is in charge of a central station with an output of about 1,500,000 kw.-hr. per annum. During the summer months we have very little load, which means that we have to run the engines light several hours each day, as we must have current on the line and stand ready to serve. This brings our coal costs very high per unit generated during the summer months.

We were sure that in spite of our poor load factor the firemen could do much better if they would only take an interest in their work. The problem was how to get them interested. We have had a large notice board put up in the boiler house and on squared paper we plot the units generated, and the cost of coal per unit generated each week.

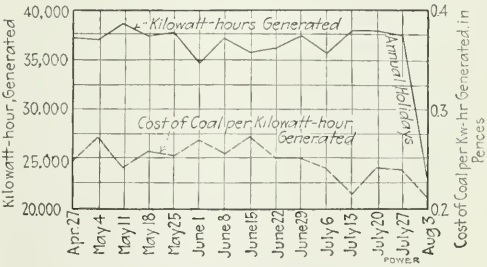


CHART POSTED IN BOILER ROOM

The chart was posted in the boiler house sometime ago and we are more than pleased with the results. A notice is posted each week with remarks about the curve and the quality of coal, etc.

The average coal cost for May and June was 0.257 pence per unit generated while the cost for July was down to 0.232 pence.* The firemen and others in the plant are taking a great interest in the chart and we are confident that they will bring the cost lower still. The saving in July over May and June is 0.025 pence per unit generated and this taken on 1,500,000 units per annum

*One pence equals 2 (U. S.) cents, or 2.03 cents, to be exact.

accounts for £150 ($750). Nothing has been done in any way to improve the efficiency of the plant, the saving being due entirely to the efforts of the men and the firemen in particular. The initial outlay is nothing and in our case the saving is well worth the trouble.

A CO_2 recorder is now installed and a CO_2 curve will be plotted on the chart. This will lend additional interest to the chart and it will also reveal who is responsible for low CO_2 percentages.

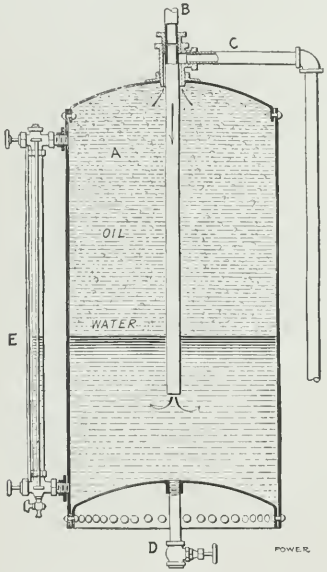
F. Riley.

Manchester, Eng.

A Simple Oil Separator

We have a home-made gravity-oiling system very much the same in general principles as other gravity systems using compressed air for delivering the oil from one height to another.

We, however, encountered one difficulty which was very annoying, that was the condensation in the air pipes accumulating in the gravity tank. This water would come



A Simple and Positive Oil Separator

down with the oil in slugs and give trouble in lubricating the bearings. After two or three experiences with hot bearings, due to this water, we designed the separator shown.

The tank or drum *A* of the separator is of convenient size, holding perhaps 10 gal. and is connected in the main delivery line leading from the gravity tank, the pipe *B* being the inlet which is extended to within 6 or 8 in. of the bottom. The pipe *C* connected to the top of the tank is the outlet. A gage-glass *E* is fitted to the side, as shown, and shows at a glance the amount of water collected. The separator is located at a convenient place near the floor so that the water may be drawn off as often as is necessary by opening the valve *D*.

A. S. Peterson.

Shawnee, Okla.

Examination Questions; First-Class N. Y. City License

Where should the feed-water connection be placed on a boiler? Why?

How would you determine the size and number of stay-bolts to be used in a boiler?

How many cubic feet of steam at atmospheric pressure weigh one pound?

How is a hard patch put on a boiler, and when, due to its position, cannot it be riveted?

How far apart should ¾-in. rivets be spaced on a boiler?

How should the gage-glass be put on a boiler?

If too little air was admitted into a furnace, what would be the result?

State all the advantages of superheated steam?

How would you find the total stress or strain on a flat surface held by stays?

Draw an indicator diagram one stroke only, showing expansion line, effect of leaky piston, admission line, leaky valves and too much compression?

What is the horsepower of an engine 16 in. in diameter, 32 in. stroke, 80 lb. pressure and 90 r.p.m.?

State the difference in action between the throttling governor and the automatic governor?

What is a cam? What is its use?

How would you proceed to set a piston valve?

State the advantage of the drop cutoff in Corliss engines over the riding cutoff in other engines?

Why is the economy of an engine never expressed in pounds of coal?

What is meant by initial pressure?

What is the advantage and disadvantage of a keyed eccentric?

Is it possible to maintain a perfect vacuum in an engine?

Is it advisable to lift the brushes off the commutator while it is in motion?

Can a commutator be taken off when worn?

What causes a dynamo to motorize?

If part of the insulation should be worn off a live wire some place in the line and the wire came in contact with metal, what would happen?

What causes the brushes of a dynamo to spark?

How would you know when to move the quadrant of a dynamo?

How do you determine the head pressure of an ice machine?

State the difference between single- and double-acting ammonia compressors?

What is meant by the terms ammonia-absorption plant; brine system; direct-expansion system?

What is the function of the pressure tank, and to what part of the plant is it connected?

What causes ammonia compressors to burst?

Frederick G. Lemke.

New York City.

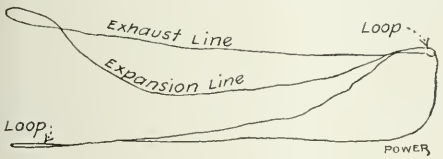
[The above is of interest only as showing the *character* of questions asked. Few, if any of them, are likely to be asked again, hence one needs to understand the subjects involved rather than to know the answers to these specific questions.—Editor.]

QUESTIONS BEFORE THE HOUSE

Comment on Freak Diagrams

In POWER, June 17, page 869, John T. Sharp, Jr., asks for comment on indicator diagrams submitted.

To begin with, the diagrams are not complete since the atmospheric line is absent. Examination of the diagrams under a glass shows a loop on both ends of one diagram and one loop at the exhaust on the other. The loop at the exhaust end of the diagram with two loops, as indicated in the illustration, is caused by the whole of the expansion line being below the exhaust line, and is



SHOWING IMPERFECT DIAGRAM

not caused by too early cutoff, as is the case with the card showing only one loop.

The upper line of the diagram with two loops I believe represents the exhaust line, and the lower line is the expansion line. This was caused by the motion of the indicator drum being interfered with somehow. Possibly someone took hold of the cord or something fell on it and threw it out of time with the events of the stroke, and the diagram was made before all the events of the stroke was completed.

The drum should have been turning to the left when it was turning to the right. This gives initial pressure of exhaust, which the diagram with two loops shows. I believe that the position of the diagram with two loops, i.e., relative to the position of the other diagram, is due to the card being moved on the indicator drum after the diagram with one loop was taken and before the other was taken. A 70-lb. spring was too strong. For the pressure, a 30-lb. spring would have been strong enough.

THOMAS C. ROBINSON.

Fort Madison, Iowa.

Slippage of Reciprocating Pumps

Referring to Mr. Newbold's comment on the above subject, page 792, June 3 issue, Mr. Newbold is in error when he believes that crank pumps do not have the "get-away" action of the direct-acting pumps, thus allowing more time for the valves to "nest home." Just the opposite is true. It is a peculiarity of the duplex pump, that the pistons remain at rest at the end of a stroke for a certain time (about ⅛ of the time required for one stroke), allowing the valves to come down to the seats. With flywheel pumps the piston reverses instantly and for this reason, power pumps must be run slower than duplex pumps or must have larger valve area; otherwise, the valves will slam and produce objectionable results.

A. REDDING.

Buffalo, N. Y.

The Engineer's Chair

In the June 17 issue of POWER there appeared an editorial under the heading, "The Engineer's Chair," which I found particularly interesting. However, I cannot entirely agree with the conclusions arrived at. The general proposition that an engineer who has to be kept continuously on his feet, to make sure that he will attend to his work properly, ought not to be trusted with the care of a plant at all, sounds well enough, and I believe, myself, that any rule specifically forbidding the man on duty in the engine or boiler room from sitting down when he is not needed on his feet is foolish. Nevertheless, experience has convinced me that it is a serious mistake to put chairs or other furnishings in the average engine room in such numbers or of such a kind as to invite the attendant to sit down or to make sitting too comfortable for him; especially is this so in plants which run at night.

A few years ago, I was fireman and assistant engineer in an electric-lighting and power plant where the load was so light during the Christmas week that it was usually not necessary to keep more than one man on duty at a time. During this period, the two of us who were ordinarily on duty together every night would take turns about in keeping things going, each of us thus getting every other night off. Returning to town about 1 o'clock on one of these nights, I was surprised to find that every incandescent lamp that I could see had its filament just barely glowing. A few minutes later I discovered the engineer fast asleep on an old sofa which we had brought into the engine room from a club house in the neighborhood. He had 10 lb. of steam and not a drop of water in the boiler gages. This man was a good, dependable engineer, but he said that when he sat down to rest for a moment, he fell asleep before he realized that he was even sleepy.

In a later experience of mine, the day man in a plant of which I was in charge, exercised his ingenuity in some of his spare moments in making what was the best model of comfort I have ever seen in the way of a chair constructed of rough boards and course bagging. In spite of my misgivings, I allowed this thing to remain in the engine room, only to be called out of bed at 4 o'clock a few mornings later with the cheerful news that both the main bearings and the crank bearing on a large engine had been burned out. The nap for which the presence of that chair was mainly responsible cost us at least $1000 before the damage was all repaired.

As to reading in the engine room, like the writer of the editorial referred to, I believe in encouraging the operating engineer to read technical journals. It is a mighty poor sign when an engineer is not sufficiently in love with

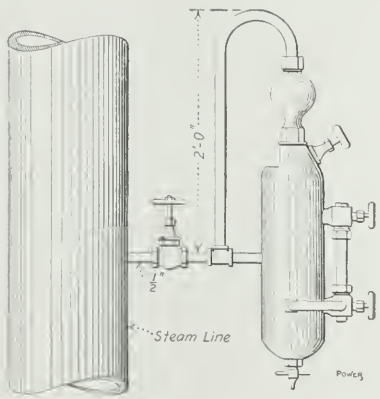
as chosen work to read all of these that he can. But, in my opinion, the engine room is not the place to read. A good man can usually find enough to do to leave him but little or no time for chair warming and reading in his regular working hours.

J. E. Latta.

Chicago, Ill.

What Becomes of the Water

Mr. Thurston, in Power, June 17, page 869, states that he is having trouble with his sight-feed lubricator on account of the water leaving the glass when the engine is shut down. I have had similar trouble with two vertical 7x7-in. piston-valve stoker engines. These engines are connected to a fan, one on each end, one being used at a time. They are controlled by a balanced valve on the steam line which is connected to the damper regulator. The engine runs very intermittently, from 140 to 450 r.p.m. There was a single-connection lubricator connected to each engine between the regulating valve and the cylinder. Every time the steam was cutoff by the damper regulator, bubbles, which appeared to be air, would pass up through the glass taking the water with



Unusual Connections for Double-Connection Lubricator

it, and the oil would pass through the needle valve in a stream, although when the engine was running or after it had slowed down no trouble was given in feeding the oil. I think the reason was, in this case, that a vacuum was formed in the steam line, as the engine ran at high speed several seconds after the steam was shut off, due to the momentum of the heavy fan. This not only caused the water to evaporate, due to reduced pressure, but may have drawn some air in around the glass packing, which in passing through the glass, took some of the water with it. Possibly the design of the lubricator had something to do with it. One of the engines still gives the same trouble. The other one was stopped by changing the lubricator.

The steam pipe to which the lubricator is connected is vertical and a double-connection lubricator was put on but not in the usual manner. The accompanying sketch shows the double-connection lubricator connected to one connection in the steam line. There is a short ½-in. nipple screwed into the steam line with a valve, a second nipple, a tee, and another nipple to which the lubricator is connected. The loop from the tee to the top of the condensing chamber is about 2 ft. high. This lubricator gives absolutely no trouble, and has been in use nearly a year. It was put on in this manner because it was impossible to turn the steam off long enough to drill and tap a hole for the top connection.

A double-connection lubricator usually gives better satisfaction than a single connection, possibly that is partly the reason why the trouble was stopped when we made the change. Incidentially it might be said that this manner of connection is a satisfactory one in which a double-connection lubricator may be used on a horizontal pipe. In regard to Mr. Thurston's trouble, my impression is that it is due to evaporation, and vacuum, and if the practice of closing the valve in the oil line to the cylinder stops it, that is the way I would shut down.

J. C. Hawkins.

Hyattsville, Md.

Mr. Thurston's trouble with the water disappearing from the sight-feed glass of a lubricator, as related in the June 17 issue is very similar to an experience I once had.

Shortly after taking charge of a new plant, I noticed that every time I made my rounds I found the lubricator on a certain engine empty. I called the oiler's attention to it, and he told me that none of the oilers had been able to keep any oil in that lubricator. On examining the lubricator more closely, I found the trouble to be in the way it was connected. Both connections entered the steam pipe below the throttle, and as soon as the throttle was closed the vacuum took the oil and water out of the lubricator. The only remedy was to close both connections to the lubricator before closing the throttle.

I think if Mr. Thurston will investigate the throttle valve closely he will find that the disappearance of water from the sight-feed glass is due to the vacuum, and not to evaporation, as he seems to think.

S. F. Farley.

Galveston, Tex.

Cause of Corroded Tube Ends

In answer to Sydney Whitaker's letter, in the June 17 issue, relative to corroded ends of boiler tubes would advise that I have had similar experiences and I have come to the conclusion that when tubes were put in they were rolled too hard and sheared, or cut slightly and corrosion started more easily on account of flues weakened condition. I think if engineers would use a bushing and a little judgment and less muscle when using the expander there would be less sheared and leaky flues.

Breckenridge, Mo. Andrew Blair, Jr.

[It is claimed by some well versed in the study of metals and corrosion that weakened steel or iron is more subject to corrosive agents than metal that has not been strained.—Editor.]

Why Engines Rock

Replying to H. R. Low in the issue of July 1, I would advise that excessive rocking of an engine in most cases is caused by too much compression. The remedy is obvious.

Louisville, Ky. John F. Hurst.

INQUIRIES OF GENERAL INTEREST

Safety-Valve Setting—How can it be determined at what pressure a safety valve is set to blow?

R. B.

By testing with hydrostatic pressure, i.e., filling the boiler with water and pumping in more with a hydrostatic test pump until the safety valve opens. The pressure then shown by the gage on the pump will indicate the valve setting.

Metal Melting Points—What are the melting points of babbitt and zinc?

A. C. H.

Zinc melts at 786 deg. F. Commercial babbit metal is made in a variety of proportions of copper, antimony, zinc and frequently lead with an average melting point of about 1000 deg. F.

Rate of Spring Flow—What is the best way to measure, approximately at least, the rate of flow of water from a spring?

W. K. G.

The best and most convenient way is to measure the discharge by a weir. A complete description of the construction and use of weirs is given in "Power," Dec. 28, 1909, pages 1090-1094.

Exhaust Steam Heating Better—We are heating the mill with live steam at 90-lb. pressure, saving the returns for boiler feeding. Is this more economical than using exhaust steam?

G. W.

Exhaust steam would be more economical for heating than live steam, but the piping must be large enough to deliver the steam at the lower pressure.

Turbine vs. Engine Economy—How does a 300-hp. turbine compare in economy with a four-valve high-speed engine of the same rating, both exhausting to the atmosphere and operated at full load?

G. W.

A 300-hp. turbine of average good construction exhausting into the atmosphere, would be about half as economical as an average good noncondensing four-valve engine.

Boiler-Tube Ends—Why should water tubes be flared at the ends, while fire tubes are beaded?

R. B.

Fire-tube boilers should have the tubes beaded over at the ends to insure that the tubes stay the flue sheets or heads of the boiler. It is sufficient to simply flare the tubes of a water-tube boiler as the reacting-pressure area to be supported is less per tube, amounting to only the cross-sectional area of the tube.

Hydraulic Accumulators—Why is it necessary to have an accumulator on a hydraulic system? Would the system not work without one?

E. J. M.

It is necessary to have an air-pressure accumulator or else a weighted plunger accumulator in a hydraulic system to maintain steady pressure. Pumping directly into the system would not insure steady working pressure. Using an accumulator not only makes steady pressure, but also permits of using the system to a considerable extent without running the pumps—depending on the capacity of the accumulator.

Hard and Soft Patches—What is the difference between a hard patch and a soft patch?

E. S.

The term "hard patch" signifies that a boiler patch is riveted in place, usualy heing put on the inside of a boiler shell for covering a hole made by removing a bad spot in the shell.

"Soft patch" is the name given to a patch which is carefully shaped to the space to be covered and goes on the outside of the boiler. Usually the patch is held in pace by screw bolts or cap screws which are screwed into holes tapped into the boiler shell. The screw bolts are usually collar-head cap screws and the square heads are chipped off after the bolts are set up, leaving the collars to hold the patch to the shell. Soft patches are frequently used to cover cracks in boiler shells and the fact that soft copper or lead is generally used as a packing between the patch and the boiler shell is the probable reason for calling a repair of this kind a "soft patch."

Safety-Valve Area—How would you determine the required area of a safety valve for a given boiler?

R. B.

The U. S. inspectors' rule for area of all safety valves determines the area by the formula:

$$a = 0.2074 \times \frac{W}{P}$$

where

a = The area of safety valve in square inches per square foot of grate surface;
W = The pounds of water evaporated per hour per square foot of grate surface and
P = Absolute pressure per square inch (working gage pressure + 15).

The value of "a" multiplied by the square feet of grate surface gives the area of safety valve or valves required.

Economical Cutoff—We have a 500-hp. engine which cuts off at half-stroke when developing this power. Our load is constant and 250 hp. Would it be more economical for us to get an engine whose rated load is 250 hp. when cutting off at half-stroke?

E. M. W.

No. From a table of mean forward pressures it can be found that for the above conditions and at half stroke the mean forward pressure is 0.8556 lb. per lb. of initial pressure, assuming 5 per cent. clearance. Assuming 100 lb. abs. initial pressure the mean forward pressure would be 85.56 lb. Also, assuming 17 lb. absolute back pressure, the mean effective pressure would be 68.56 lb. For half the load the mean effective pressure would be

$$\frac{68.56}{2} = 34.28 \text{ lb.}$$

Adding the 17-lb. back pressure the mean forward pressure would be 51.28 lb. or 0.5128 lb. per pound of initial pressure, which from the tables is found to correspond to a cutoff of less than $\frac{5}{8}$-stroke and a little more than $\frac{1}{2}$-stroke. In any event it shows that less than half the steam will be admitted per stroke and, speed remaining the same, the steam consumption will be less than it would with cutoff at half-stroke.

Tank-Head Strength—The bumped head of a cylindrical tank is ¾ in. thick, 30 in. in diameter, the radius of curvature is 30 in. and the tensile strength of the material 60,000 lb per sq.in.; with a factor of safety of 4 what is the safe working pressure?

R. J.

The ultimate strength can be found from one or the other of the following formulas:

$$p = \frac{2St}{r} \quad \text{or} \quad p = \frac{2St}{d}$$

where

S = Tensile strength, pounds per square inch;
t = Thickness of the material;
r = Radius of curvature of the head;
d = Diameter of the head.

The right formula to use in any case is the one in which the value "r" or "d" is the larger. In this instance they are equal, hence either formula will do and to get the working pressure for a factor of safety of 4 it is necessary to divide "p" by 4 and since

$$p = \frac{2St}{r}$$

$$\frac{p}{4} = \frac{2St}{r4} = \frac{2 \times 60{,}000 \times 0.375}{30 \times 4} = 3750 \text{ lb. per sq.in.}$$

ENGINEERS' STUDY COURSE

Heat Lost in Flue Gases—III

SOLUTION OF PRACTICE PROBLEMS

The percentage of excess air supplied to the furnace may be determined from the formula for calculating the ratio of air supplied to air required, which is as follows:

$$R = \frac{N}{N - (3.78 \times O)}$$

From the data given, N, the percentage of nitrogen in the flue gas, equals

$$100 - (6.3 + 11.7 + 0.4) = 81.6$$

Substituting in the formula gives

$$R = \frac{81.6}{81.6 - (3.78 \times 11.7)} = \frac{81.6}{37.37} = 2.18$$

Thus, 2.18 lb. of air was supplied for every pound theoretically required. Hence, the amount of excess air supplied with each pound required is

$$2.18 - 1 = 1.18 \text{ lb.}$$

This excess amount divided by the required amount and multiplied by 100 gives

$$\frac{1.18}{1} \times 100 = 118 \text{ per cent.}$$

excess air supplied to the furnace.

To calculate the B.t.u. carried up the chimney by the flue gases per pound of coal burned it is first necessary to estimate the weight of flue gases formed per pound of coal. And before this quantity can be estimated it is necessary to estimate the decimal part by weight of total carbon in the fuel. The decimal part of fixed carbon is given (expressed as a percentage) in the promixate analysis of the coal, and equals 0.652. To this must be added the decimal part of volatile carbon, which is estimated in the manner explained in the lesson of July 22 by means of the chart in Fig. 1. The sum of the percentages of fixed carbon and volatile matter is 65.2 + 18.6 = 83.8, and this, divided into the percentage of volatile matter and multiplied by 100, gives

$$\frac{18.6}{83.8} \times 100 = 22.2$$

the percentage of volatile matter in the combustible.

Locating as closely as possible the 22.2 per cent. point at the bottom of the chart in the July 22 number, and tracing an imaginary line up to the curve and over to the side scale, we get 10.4, the percentage of volatile carbon in the combustible. And this, multiplied by the percentage of combustible in the coal (83.8) and divided by 100, gives

$$\frac{10.4 \times 83.8}{100} = 8.7$$

the percentage of volatile carbon in the coal. Shifting the decimal point two places to the left reduces this percentage to a decimal fraction. Adding this fraction to 0.652, the decimal part of fixed carbon in the coal, gives

$$0.652 + 0.087 = 0.739$$

or practically 0.74, which is the decimal part of total carbon in the coal.

The formula for estimating the weight of gases formed per pound of coal burned is

$$W = 3.032\ C \left(\frac{N}{CO_2 + CO} \right) + (1 - A)$$

Substituting, gives

$$W = 3.032 \times 0.74 \left(\frac{81.6}{6.3 + 0.4} \right) + (1 - 0.117)$$

$$W = 2.24 \left(\frac{81.6}{6.7} \right) + 0.88 = 28.16 \text{ lb.}$$

gases formed per pound of coal burned.

The B.t.u. carried up the chimney per pound of coal burned is estimated by this formula.

$$L = 0.24\ W\ (T - t)$$

Substituting, gives

$$L = 0.24 \times 28.16\ (515 - 75)$$

$$L = 6.76 \times 440 = 2974 \text{ B.t.u.}$$

carried up the chimney by the flue gases per pound of coal burned.

The percentage of loss is the number of B.t.u. carried up the chimney per pound of coal divided by the heat value of the coal and multiplied by 100, thus

$$\frac{2974}{13,160} \times 100 = 22.6 \text{ per cent. loss}$$

There are several ways in which the answer to the last problem can be obtained. The simplest, although, perhaps, not the shortest, is to find the percentage of heat loss in the second case and subtract this loss from the loss we have already worked out for the first case. The difference, divided by the heat value of the coal, will represent the percentage of coal saved per year. Then, the number of tons thus shown to be saved, multiplied by the cost per ton, will give the annual saving in dollars and cents.

First, using the formula for the weight of flue gases formed, gives

$$W = 3.032 \times 0.74 \left(\frac{81.6}{10.7 + 0.4} \right) + (1 - 0.117)$$

$$W = 2.24 \left(\frac{81.6}{11.1} \right) + 0.88 = 17.34 \text{ lb.}$$

the weight of flue gases formed per pound of coal.

Next, substituting this value in the formula for estimating the heat lost up the chimney, gives

$$L = 0.24 \times 17.34\ (515 - 75)$$

$$L = 4.16 \times 440 = 1830 \text{ B.t.u.}$$

carried up the chimney by the flue gases per pound of coal.

In the first case, 2974 B.t.u. was lost up the chimney per pound of coal. Hence the saving is

$$2974 - 1830 = 1144 \text{ B.t.u.}$$

per pound of coal. In percentage this saving amounts to

$$\frac{1144}{13,160} \times 100 = 8.69 \text{ per cent.}$$

As 8.69 per cent. of each pound of coal is saved, 8.69 er cent. of each ton and hence 8.69 per cent. of all the oal is saved. Thus, the saving in tons per year equals

$$\frac{6200 \times 8.69}{100} = 538.78$$

nd the saving in dollars and cents equals

$$538.78 \times 3.10 = \$1670.22$$

Loss Due to Incomplete Combustion

In one of the early lessons we learned that carbon un- er certain conditions will only partially burn, forming rbon monoxide (CO) instead of carbon dioxide (CO_2) nd creating only 4450 B.t.u. per lb. of carbon instead 14,600. Hence, for every pound of carbon only partially rned

$$14,600 - 4450 = 10,150 \text{ B.t.u.}$$

lost.

If the flue-gas analysis shows that CO exists it may be nportant or desirable to know the amount of heat loss ue to incomplete combustion. The following formula convenient for estimating this quantity.

$$L' = 10,150 \left(\frac{CO}{CO + CO_2} \right) C$$

Where

L' = B.t.u. lost per pound of fuel;
CO = Percentage by volume of carbon monoxide in the flue gas;
CO_2 = Percentage by volume of carbon dioxide in the flue gas;
C = Decimal part by weight of total carbon in the fuel.

To illustrate, assume the following: CO, 1.3 per cent.; O_2, 15.2 per cent., and total carbon in the fuel, 72.8 r cent. The heat loss due to incomplete combustion ould be, in such a case,

$$L' = 10,150 \left(\frac{1.3}{1.3 + 15.2} \right) 0.728$$

$$L' = 10,150 \times \frac{1.3}{16.5} \times 0.728 = 582.27 \text{ B.t.u. per lb.}$$

Control Board for Panama Locks

The first of the control boards for the Panama Canal cks has just been completed by the General Electric o. Before shipping to the canal zone, however, it was sembled and a demonstration of its operation given fore a number of guests at the Schenectady works on uly 28.

The board is of the bench type, about 60 ft. long, and unique in that its top represents a plan of the locks ith all the gates, etc., in miniature; these operate simul- neously with the actual gates. A system of water-level dicators is provided, as well as signal lights showing e positions of the valves.

By an ingenious system of interlocking the operator prevented from throwing any of the switches in the rong sequence, which makes the board practically fool- roof.

At a later date we hope to illustrate and describe the ard more in detail.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"A boiler explosion broke the right leg of Rufus Palmer last Friday, on the farm of Robert Liddell, northeast of Columbia, where Mr. Palmer was threshing wheat," says the Columbia (Mo.) "Herald." Beats all how a boiler explosion sometimes cuts up. It might be some consoling that the dratted thing broke the right leg, whichever one that was.

This comes from Kansas: "Farmer David Rump has a calf that is 16 in. high." Goodness only knows what a boiler explosion would do to Dave's calf. From the meager press details, one is at a loss as to whether Dave ought to cover his calf with a pink silk sock, or tether it out in the red clover and let it bark at the passing automobiles.

Out of 10,000 names in a straw vote as to "the most useful American," Thomas A. Edison received 87 per cent. of the ballots cast. It's not surprising that Edison should get this recognition. A woman, Jane Addams, was second choice. For years, remarks "Valve World," this noble woman has been quietly putting into practice "a human method of helping the poor"— and helping them to help themselves. In its own grooves, this work is as great as that achieved by Edison.

My stars! Efficiency is now roaring up into the blue vaults of high heaven—gone up in the air, as it were. The leading astronomers are adapting its methods to their particular needs. Now who will tackle the bottom of the sea and stir up our old friend McGinty?

A man in Oklahoma thinks that "the boiler explosion was caused by too much pressure in the boiler." It's a pretty good guess at that, unless the boiler may have become infested with boll weevils.

Hoch Deutschland! Hoch der American Society of Mechanical Engineers! Those who attended the recent international convention at Leipzig had the time of their lives and they live to tell it. On arrival, their hospitable German hosts took them to their hearts—and to the Hofbräuhaus. In fact, the 18 days' visit was a succession of banquets and lunches, 28 in all—a regular endurance test. But in between they saw things and learned things that will endure for a lifetime. They're glad they tore themselves away from Yankeeland that they might dip into the good things of the Fatherland.

The Congressman electrician who proposes the installation of an electric voting machine in the national House lays himself open to the suspicion of pernicious activity. He would record his vote by pushing a button. In a hotel café this is productive of the desired results, but it is prostituting congressional dignity to attempt it in the House.

Can you dope this out as you read it? "A man leaves his working face before shooting time, expecting his buddy to fire all the shots, but the buddy is injured by a windy shot and can't make his way out," says "Coal Age." This partly describes a coal-mine accident; it's the slang technique of the miner.

"Pencil scribblings no longer deface the walls of our toilet rooms," reports a shop manager in "Factory." Oh ye poets and cartoonists, what a blow to an active industry! Friend manager has dealt this blow by removing the stall doors; the frequenters are, therefore, under more or less surveillance.

The digging is always good in Rome, Italy. Apparently, if one is hazy as to the origin of any old kind of engineering, he has simply to take a Roman excavation trip—and he's got it. In the first century Roman houses were heated by a primitive system of hot-air circulation; there were three large elevators in the Imperial Palace; there were hot- and cold-water services—mebbe, the early wise guys knew if the foot-pound wabbled. The pick and the shovel have heretofore been belittled by the ignorant and the thoughtless;; now it's time to buck up.

Mechanical Engineers' German Meeting

By F. R. LOW

Notable among the increasingly frequent international exchanges of courtesy is the entertainment extended by the Verein Deutscher Ingenieure to the members of the American Society of Mechanical Engineers who accepted the invitation to take part in its summer meeting at Leipzig. The visiting party numbered upward of 300, most of whom left New York on the "Victoria Luise" on June 10.

Representatives of the Verein boarded the ship at Plymouth, England, to welcome the visitors and explain the arrangement which had been made for their comfort, convenience and entertainment.

Being somewhat behind her schedule, the "Victoria Luise" landed her passengers at Cuxhafen whence they proceeded by train to Hamburg where they arrived late in the evening of Thursday, June 26.

AT HAMBURG

On Friday forenoon the company assembled at the Landing Stage Restaurant of the river steamers where after breakfasting they listened to a lecture about the Harbor of Hamburg and the tunnel under the Elbe by Geheimrath Bubendey who is responsible for much of the recent work, and then took an excursion about the harbor in steamers.

In the evening a reception was tendered to the visitors by the Senate of Hamburg, which is one of the free cities, a miniature republic with a government of its own. The address of welcome was made by the Lord Mayor, and an opportunity was offered to inspect the magnificient Rathaus, the seat of the local government. A banquet tendered by the Hamburg Section of the Verein Deutscher Ingenieure in the Rathskeller beneath the same building completed the evening's entertainment.

On Saturday the tunnel under the Elbe, a municipally owned project with two driveways and two sidewalks, and with elevators at either end for teams and passengers was inspected. It was a pleasure to notice that the elevators were American, made by Otis. The party was then taken to the ship-building yards of Blohm & Voss where among other interesting things the "Vaterland" (55,000 tons, five tons larger than the "Imperator") was on view. After lunching at the yards the party was taken to the power station of the elevated railroad at Barmbeck whence after being further refreshed they proceeded to the Hagenbeck Zoological gardens, the attractions of which were explained by the younger Mr. Hagenbeck himself. The evening was thoughtfully left free and profitably employed in viewing the interesting points of the city itself.

AT LEIPZIG

Sunday the 22d was spent in going from Hamburg to Leipzig where the party arrived late in the afternoon, in time to witness the flight of several Zeppelins. Here the attendants at the Leipzig meeting were already assembled and the first union of the guests with the greater body of their hosts took place at a tremendous reception at the Crystal Palace, I use the word advisedly for everything, company, place and entertainment was upon a large and generous scale, and of an informal character which afforded an excellent opportunity for the initial amalgamation.

On Monday morning the opening session of the general meeting of the Verein Deutscher Ingenieure was held in the Central Theater and it is an index of the esteem in which the engineer and this his professional organization are held in Germany that H. M. the King, Friedrich August of Saxony,

ONE OF THE TEN AUTOMOBILES USED IN THE DRIVE TO WANNSEE, JUNE 28

was pleased to be present and to be "promoted" to Doctor of Engineering. Count Zeppelin was also there and spoke briefly and the Grashof medal was awarded to George H. Westinghouse.

At the conclusion of the award of honors, Dr. Lamprecht presented a paper upon the "Technical Science and Culture of the Present," and Dr. W. F. M. Goss' paper upon "Influences Affecting American Engineering Practice" (abstracted in "Power," July 1, 1913, page 38) was presented in Dr. Goss'

A GROUP OF THE ENGINEERS AT THE WORKS OF THYSSEN & CO., MÜLHEIM, GERMANY, JUNE 30

absence by Past-President Jesse M. Smith. One of the most enjoyable features of the whole trip was a concert at the Gewandhaus tendered by the Senate of the city of Leipzig by an orchestra of nearly 100 pieces. This was followed by a banquet in the large festival hall of the Central Theater, in the course of which several numbers were rendered by the Thomaner-Boy Chorus founded by J. Seb. Bach.

Tuesday's session of the Verein was held in the lecture room of the Architectural Exhibition, there in progress. Opportunity was afforded to view the exposition, to visit several local industries and to take part in the dedication of the monument to the "Battle of the Nations." The evening party in the Palm Garden was somewhat disorganized by a violen

hunder storm, especially the intended celebration of the olstice on the lawn and the illuminations and fireworks.

AT DRESDEN

Leaving Leipzig the party arrived at Dresden before noon, nd at two o'clock was taken to the Bastei (the Switzerland f Saxony) returning as far as Pirna by steamer on the Elbe nd thence to Dresden by special train. In the evening a re-eption and banquet were given the visitors in the Town Hall y the city of Dresden.

The following forenoon was devoted to sight-seeing. At he Mechanical Engineering Laboratory of the Technical High chool, where Professor Mollier, author of the steam tables nd the Total Heat-Entropy diagram which bear his name, scorted the visitors through his department. Interesting ork upon heat interchange between an exploded charge of as and the metal of the containing vessel involving the de-

Two Sides of the Medal Struck in Commemoration of the Meeting

ermination of the specific heat at constant volume were in rogress. Another interesting feature was an engine pro-ided with a delicate apparatus at every working bearing to ndicate and analyze knocks. We hope to be able to treat hese researches more fully later. Other points of attraction ere the local industries, the picture gallery and the Green ault where the crown jewels are displayed. The visit to resden ended all too quickly with a luncheon tendered by the ocal division of the Verein and at 2:30 the party took its pecial train for Berlin.

AT BERLIN

To do Berlin in two days was beyond the power even of this ow some experienced group, but it made a frantic try at it. n a little over two hours after the train reached the city the isitors were at a reception in the Palace of the Imperial iet. Friday and Saturday they visited many of the local in-ustries and the Royal Technical High School at Charlotten-erg. Saturday afternoon they were taken in automobiles or a drive over the famous Heerstrasse to Wannsee, given a teamer trip on the Havel, and a farewell supper in the Swed-sh Pavilion at Wannsee.

AT DUSSELDORF

It is an all-day ride from Berlin to Düsseldorf, the next topping place. The party arrived there late on Sunday after-oon and was given a reception in the Tonhalle by the city f Düsseldorf at which Dr. Frohlich, secretary of the Vereins eutscher Maschinenbau-Anst, read a paper upon the "Rhen-sh-Westfalian Industries," illustrated by lantern slides. This as followed by an opportunity for social intercourse with he refreshments without which no occasion here is complete.

Monday was devoted to visiting various industries and an nspection of the harbor, with a banquet in the evening given y the Rhenish-Westfalian Committee of the Verein. The eature of the evening was an allegorical play in which a uge billet of red-hot steel was flattened out under the forge ress and when turned up revealed the emblems of the erein Deutscher Ingenieure and the American Society of echanical Engineers embedded in the apparently glowing et: l.

Tuesday was again devoted to visiting industrial estab-shments by the men and to auto rides and visits to the art alleries by the ladies. A dainty lunch was served at the Malkasten," an artists' club, and the party moved over to ologne only an hour away in time to see something of the ity and dress for the "Evening on the Rhine." The pro-ram announced that "Supper and fun" had been prepared by he Rhenish-Westfalian committee and there was no lack f either notwithstanding the cold and damp weather pre-vented them from being served upon the lawn as the feature of a regular Abend am Rhein should properly be. Particularly enjoyable was the singing by the Cölner Männergesang-verein, a male chorus of over a hundred voices, which has held the emperor's prize for a number of years.

AT COLOGNE

On Wednesday an opportunity was afforded to visit the industries of Cologne and the vicinity, the museums, etc., and the cathedral, the ladies and gentlemen of the local committee acting personally as guides and interpreters. In the evening a reception and banquet was given by the city of Cologne in the historic old Gürzenich built by the city in 1441-1447 for festival and similar purposes, serving for the ceremonial receptions of the emperors Frederic III and Maximilian I in the 15th century, of Charles V in the 16th century, and an imperial diet of Maximilian in 1505 and the meeting of the Electors to choose King Ferdinand I in 1531.

AT FRANKFORT-ON-THE-MAIN

On Thursday the visitors started on their journey up the Rhine going by train to Corblenz, then by boat to Rüdesheim and thence by rail to Frankfort-on-the-Main, where they were received by the Frankfurter Bezirk Verein, Deutscher Ingenieure. The evening was spent in the Palm Garden, with feasting, music and special illumination.

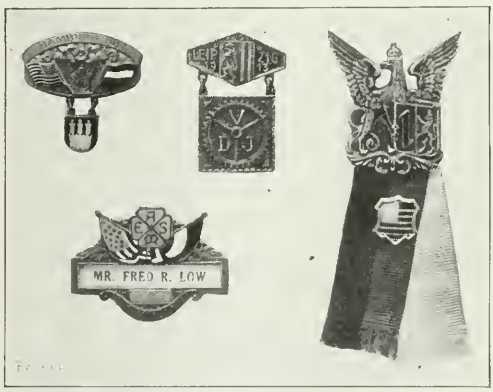
At noon of Friday, the fourth, luncheon was given in the Römer by the city of Frankfort and an opportunity afforded to inspect this and the neighboring old Guild houses. In the afternoon the party divided into groups for the inspection of various shops and factories. In the evening the Americans became the hosts, inviting the officers of the city and the Verein and the committee to help them celebrate the national holiday with a banquet in the Kurhaus Bad Homburg.

AT MANNHEIM

On Saturday forenoon the party proceeded to Mannheim where it arrived in time for luncheon. After an afternoon of sightseeing among the works for the men and of receptions at the homes of the directors for the ladies, a banquet was given by the city of Mannheim in the Nibelungensaal of the Rosengarten in the evening, at which a picked chorus of 24 male voices was a specially enjoyable feature.

AT HEIDELBERG

Sunday was devoted to a visit to Heidelberg. The inspection of the castle was somewhat interfered with by the rain, which abated, however, in time to allow the party to go in



Badges Given the Guests at Hamburg, Leipzig and Mannheim and the Official A. S. M. E. Badge

open boats upon the Neckar and see the castle illuminated and an elaborate display of fireworks upon the bridge and river bank. Heidelberg had been a bright spot in a glittering program, and notwithstanding the unpropitious weather the expectations even of the most sanguine were fully satisfied

AT MUNICH

Monday, the seventh, was spent in getting to Munich where the trip ended. It would seem as though there were nothing left that man could do to sustain the interest of this much entertained crowd and provide new sensations of pleasure and enjoyment, but the Bavarians were equal to it, and their wel

coming evening in the world-renowned Hofbräuhaus was so in keeping with the reputation of the place for good fellowship and camaraderie, so different from all that had gone before that the enthusiasm of the guests was aroused to a higher pitch than ever.

On Wednesday forenoon a visit was paid to the German Industrial Museum of which Oskar von Miller, also president of the Verein Deutscher Ingenieure, is the president. Lunch was served in the still uncompleted new building at which Past-President E. D. Meier presented the museum in the name of the American Society with the model of the Panama Canal which had been brought over for that purpose and Dr. von Miller responded by presenting the Society with an original telescope of Fraunhofer.

In the afternoon an excursion was made to the Lake of Starnberg and the closing ceremonies of the trip took place at a banquet given by the city of Munich in the old Town Hall.

A final assemblage of the party was held at the Regina Palast on Wednesday forenoon where resolutions of thanks were passed to all who had been concerned in their entertainment. Dr. Conrad Matschoss, the representative of the Verein Deutscher Ingenieure, who had visited America to convey the official invitation and arrange the preliminary details, and who had met the party at Plymouth and accompanied them throughout the trip was given a special demonstration and expressed the hope that the visit might result in the establishment of permanently pleasant relations between the engineers of the two participating nations. He also made a special plea for the preservation and record in America of the history of engineering and industry. The world's history as at present taught and accessible, recounts the reigns of kings and glorifies warriors and conquerors, but gives almost nothing of the work of the great inventors and promotors who have done more for the development of the race than those whose portraits fill the galleries and whose deeds have inspired historians, poets and painters. There should be an earnest concerted movement on the part of engineers to preserve the record of their work and impress the world with its meaning and importance. More of the veterans should record their experience as John Fritz and Charles T. Porter have done, and museums should be established, for the preservation of apparatus and machines of historical interest, and the demonstration by models of classical experiments and the development of various industries. He pleaded for the cooperation of all American engineers in the task which he has undertaken of putting the achievements of the engineer on record.

In the afternoon a visit was paid to the Technical High School where Dr. Knobloch, whose work with Jakob forms the basis of our latest knowledge of the properties of superheated steam, personally exhibited his laboratories and later Dr. Diesel received a large number of the visitors at his home.

⁂

Explosion of Traction Boiler Fatal

A traction-boiler explosion near Alva, Okla., on July 8, killed one man and severely injured two others.

It is stated that the second-hand traction engine was at least 20 years old, and that none of its type had been made in 15 years. At the time of the explosion the boiler was carrying 165 lb. pressure, but how long it had been thus subjected is unknown. A day before the accident the fusi plug blew out and an iron pipe plug is said to have been serted.

The man who attended the tractor and thrasher quit job a few days prior to the explosion because of the uns condition of the boiler. He also advised the owner to red the pressure.

About a year ago the flue bagged considerably and owner took the machine to the Alva Machine Works for pair. The manager of the works refused to repair it, stat that the machine was so weak and dangerous as to be only for the junk pile. The owner later pushed the bag b with a screw jack while the metal was cold. The flue g way at the edges of the metal where the bag was forced ba The man who was killed was blown 180 ft., and his body t ribly mangled.

The illustrations show how the machine was damaged

⁂

Minnesota State N. A. S. E. Convention

The fourth annual convention of the Minnesota State sociation of the National Association of Stationary Engine was held in Duluth on July 16, 17 and 18. Both the busin sessions and the exhibit were held in the Spalding Hotel.

Mayor W. I. Prince welcomed the delegates and visit to Duluth at the opening session on Wednesday morning, T. W. Hugo, Duluth, responded in the absence of Natio President John F. McGrath, who was delayed one day in riving. State President J. B. Crane then delivered his m sage in which he took up the subject of license laws for M nesota.

In the afternoon a boat trip was taken on the St. Lo River in a boat furnished by the Duluth Commercial C At the evening session various committee reports were s mitted and Whitney Wall, of Duluth, gave a lecture "Building Management and the Engineer."

On Thursday morning National President McGrath dressed the convention, devoting his remarks principally the ways and means of securing desired license legislat He thought much could be done by making clear the obje of license laws to all affected or interested. Emphasis laid upon the need of diplomacy. In concluding he brie reviewed the progress made during the last year by national body.

State President Crane offered a prize last year of $25 the best paper prepared and presented at this conventi Although only two papers were entered, these brought so much interest and discussion that the scheme was c sidered a decided success.

Association No. 4, Winona, entered a paper on "Heat and Ventilating." This paper was printed and copies w issued to all present. The paper discussed three systems heating employed in large buildings, namely, direct, dire indirect and indirect. In addition, a method of calculat the required amount of radiating surface for a given set conditions was presented as well as the commonly emplo factors for various kinds of walls and surfaces.

The paper concluded with a brief review of the requi ments for proper ventilation and some data were given as fan capacities.

Wreck of the Traction Engine

Where the Boiler Failed

The other paper was submitted by Association No. 7 of St. Paul, and was on the topic of "The Isolated Plant versus Central Station." The paper showed that where a private plant is installed that is capable of producing current cheaper than current can be purchased the fixed charges are not such a serious item as sometimes believed. To illustrate this point. two plants under identical conditions were compared. In one case the plant was designed to generate current and heat with the exhaust steam. In the other, current was purchased and the heating was done with live steam.

The cost of light, heat and power in the first case was $4395, and in the second $6800 per year, showing a saving of $2400 per year in favor of the isolated plant. Now if this annual saving were invested each year for 20 years at 5 per cent. interest, at the end of that period there would be a credit in favor of the isolated plant of about $67,000. If the original equipment cost $13,900, the plant could be entirely renewed, if necessary, and there still would be a clear balance of $53,100.

In view of the practically equal merits of the two papers and the large amount of interest and discusslon occasioned by both, it was decided to split the prize and award half to each association.

On Thursday afternoon another boat trip was taken, during which visits were paid to the coal docks of the Northwestern Fuel Co., the plant of the American Carbolite Co. and the blast furnace of the Zenith Furnace Co.

In the evening a smoker was given by the Central States Exhibitors' Association in the exhibit hall, Mayor Prince, of Duluth, Mayor Keller, of St. Paul, and National President McGrath made brief addresses after which a special meeting of the subordinate association of engineers in Duluth was held for the purpose of electing these distinguished guests to honorary membership. The meeting was then immediately adjourned, and the lighter part of the program taken up.

At the Friday morning session a resolution was passed favoring biennial national conventions and the following officers were elected: H. F. Mueller, Minneapolis, president; F. H. Kirchner, Winona, vice-president; James McGeary, St. Paul, reëlected secretary; J. Albert Johnson, St. Paul, reëlected treasurer; E. F. Voss, Duluth, trustee.

The next annual convention will be held in Minneapolis.

The Central States Exhibitors' Association held its annual election on Friday morning with the following results: Charles Cullen, president; C. H. Fiske, secretary-treasurer; executive committee; W. L. Osborne, S. E. Denney, Fred Grunner, H. R. Anness, E. J. Kuchenmeister, A. J. Richardson and A. J. Beckerleg; state vice-presidents, Minnesota, H. A. Gurdorf; Wisconsin, E. T. Ward; Iowa, J. H. Williamson; Illinois, A. J. Olson; Indiana, C. S. Kiessling; Kentucky, A. H. Leuter; Missouri, Joseph Deady, and Ohio, J. G. Boyer.

Grashof Medal Award

The award of the Grashof medal to George Westinghouse by the Verein Deutscher Ingenieure has aroused interest as to this medal and its significance. It can only be awarded for scientific or practical service in the realm of engineering. Its award to Mr. Westinghouse upon the occasion of the visit of so many American engineers is not, therefore, as was forcibly pointed out at the time of its bestowal, to be taken as a compliment to the American Society or to American engineers in general, but as a recognition of the work of the recipient as an engineer for the good of humanity.

The Grashof medal is 5 cm. (nearly 2 in.) in diameter, of gold, carrying upon one side the head of Franz Grashof, surrounded by a wreath, and on the other the name of the recipient and the date of its bestowal with the inscription "Grashof-Denkmünze des Vereines deutscher Ingeneures." It is awarded by the governing bodies of the Verein with the approval of living former recipients. It has previously been awarded to: C. von Bach, H. Gruson, O. Intze, F. Schisau, Gustav Zeuner, A. Wöhler, G. von Krauss, Carl von Linde, A. Riedler, Hugo Luther, A. von Rieppel, Heinrich Sulzer-Steiner, Justus Flohr, A. Slaby, Gustaf de Laval, Charles A. Parsons, Max von Eyth, Herman Blohm, E. Rathenau, Aurel Stodola, Ferdinand von Zeppelin, Ernst Körting, Carl H. Ziese, A. Martens, and Paul Mauser.

A Group of N. A. S. E. Delegates and Visitors at the Minnesota Convention

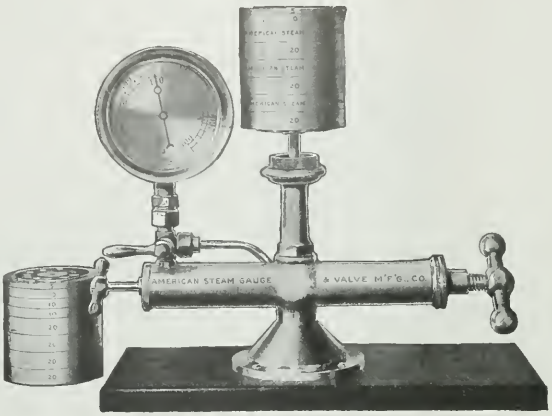
PERSONALS

Louis Streng, formerly chief engineer of the Kentucky Electric Co., Louisville, Ky., has been retained as consulting engineer by the Louisville Gas & Electric Co.

C. A. Orr, formerly chief engineer and master mechanic of the John Morrell & Co. packing plant, Ottumwa, Ia., has accepted the position of superintendent of power house and shops of the Arkansas River Valley Ry., Light & Power Co., Pueblo, Colo.

George M. Brill, M. Am. Soc. M. E., has retired from the firm of Brill & Gardner, engineers, 1134 Marquette Bldg., Chicago, Ill., and the partnership has been dissolved. Mr. Brill is at present in Germany with the visiting party of the American Society of Mechanical Engineers and will continue to spend some time in travel and study in Europe before returning to this country. The business of the firm will continue under its present name.

Don't Give Your Gauges A Chance To Lie



The American Dead Weight Gauge Tester

will keep your gauges toed right up to the "truth mark."

Gauges, if not tested regularly, fall into the natural habit of being inaccurate. Neglect in the matter of testing means a wrong record—and consequent bad firing.

Don't give your gauges a chance to lie and you will always have accurate, dependable records. To keep your gauges up to the "truth mark," it is only necessary to test them once every so often with the American Dead Weight Gauge Tester; the most trustworthy device that money can buy for the purpose. The testing is done by dead weights; the device possessing all the advantages of a mercury column, but in a smaller space.

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POWER

Vol. 38. AUGUST 12, 1913 No. 7

Pertinent Questions

Mr. Owner, Manager or Superintendent! Stop a moment and answer a few questions that are of interest to a legion of engineers.

What kind of an engineer have you in your engine room; is he the best man for the position? It is assumed that you are too good a business man to entrust an installation costing several thousands of dollars, and the lives of perhaps hundreds of people, to any but a good engineer, but are you?

Of course, you expect continuous and efficient operation—do you get it? You cannot afford to have the wheels stop turning, for that means loss of production; and you love to make the dollars, don't you? But when you hired the engineer, were you looking for just a man to run a job, or an engineer to fill a position? There is a difference.

Is the man you hired making good; is he master of the position? You are paying him a sum commensurate with the position and treating him accordingly, but is he getting enough money each week and are you treating him right?

For instance, do you give a requisition coming from him the same consideration you would give to one coming from a mill foreman? Do you ever consider that though the engineer's job may be dirty and hot at times, he must be a man of equal intelligence with other heads of departments, and that his requisition is the result of some thinking on his part?

His thinking is for your interest; to make your plant more efficient, safer and economical. Do you ever consult him about the coal you purchase, or do you let the dealer deliver anything that will burn and expect results?

Your engineer is always on call, day and night, Sundays and holidays, all the time and at any time. What does he get for his services? Is he not worth more? While you take a spin in your car, your engineer may be spinning a tube expander in the roasting back end of a boiler setting, or doing jobs that would be unnecessary if means of prevention were provided for him.

You are a business man, but don't let your business policy stop at the engine-room door. Go inside and give your engineer an opportunity to show results from his department, which he can never do without your coöperation. Your engineer has a right to feel belittled and discouraged if he is ignored, and then blamed if things do not "pan out" as they should.

It is a matter of pride with most engineers to show the best results with their equipment. Don't hand him a lemon and look for a melon in return.

[*Written by H. R. Low, Moosup, Conn.*]

Meriden Electric Co.'s New Power Station

SYNOPSIS—Owing to the increased demand for electrical energy the Meriden power plant was remodeled and the mechanical capacity of the plant increased. Coal and ashes are handled by a monorail system. Because of a scarcity of circulating water, at times, a cooling tower is used.

The city of Meriden, with a population of nearly 30,000, is one of the enterprising manufacturing cities of Connecticut. The current for street lighting, private lighting and most of the power used for manufacturing purposes is furnished by the Meriden Electric Light Co., from its new power station.

For the last few years the growth of industries in Meriden has caused a pronounced increase in the power output of the station and in 1911 it was seen that additional apparatus would have to be installed to meet the

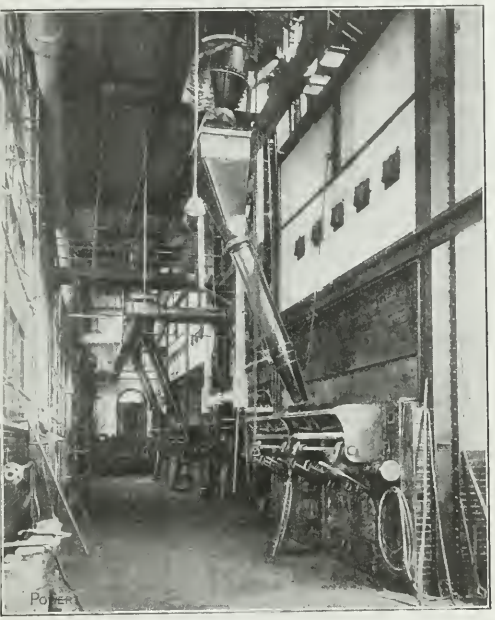


FIG. 1. BOILER ROOM

increasing demand for power, especially in boiler capacity. It was decided to abandon the old boiler equipment and install an entirely new boiler house and equipment and sufficient new turbine units to meet the needs of the plant.

The existing engine room, with slight modifications and the removal of some compound engine-driven units, was adequate for the new steam-turbine equipment. As the available property was limited in width, the new boiler house was built at the end of the turbine room. The foundations for both building and apparatus are of concrete, carried down to rock or good bearing soil. The superstructure is a steel frame and brick building with artificial stone trimmings. Above the boiler-firing aisle is a concrete and steel coal bunker of about 250 tons capacity. For the entire length of the building, along the side of the bunker, are copper louvres and below the louvres are inclined pivoted sashes which give ventilation for the boiler room and provide an adequate amount of light in the firing aisle, a feature that is often neglected in boiler-house design.

In the new boiler house are installed three 625-hp. Bigelow-Hornsby boilers, Fig. 1. Two of the boilers form a battery and the third forms half of a future battery, space being left in the building for this fourth boiler. Each boiler is equipped with a Foster superheater, designed to give 125 deg. of superheat. The boilers are fired by three Roney mechanical stokers driven by 4½x4-in. simple engines. The stoker engines are arranged so that either of two can operate all stokers.

The boilers as well as the auxiliary apparatus and piping are designed to operate with 200 lb. steam pressure and 125 deg. superheat, but owing to existing apparatus unsuited to high pressure, the safety valves on both superheater and boilers are at present set to carry 150 lb. pressure and until some of the present apparatus in the station is replaced this pressure will be carried.

Each boiler is connected to a rectangular steel smoke flue which joins the stack base between the batteries of boilers. Natural draft is furnished by a brick-lined, self-supporting steel stack 9 ft. in diameter and 150 ft. high above the boiler-room floor. The stack is supported by steel girders framed into the steel structure of the building. The stack is also used to support two large electric signs, one on either side. These signs are composed of letters 3 ft. wide and the total length of the signs is about 100 ft. The signs are used for advertising the output of the plant, one reading "Use Electric Light" and the other "Use Electric Power."

Boiler-feed water is heated in a National direct-contact or open-type, feed-water heater. Two boiler-feed pumps were installed, one being a horizontal duplex pump; the other a turbine-driven centrifugal pump. Each of these pumps is large enough to feed the boilers. A venturi meter tube is placed in the feed lines between the feed pumps and the boilers. The flow is recorded on a registering and indicating device, calibrated in pounds of water per hour. This gives a very close record of the amount of water evaporated.

The high-pressure steam piping is of welded, flanged steel pipe, cast-iron fittings and steel gate valves with monel metal trimmings. All small globe valves 2 in. in size and under have bronze body with nickel seats and disks. The condensation from the high-pressure steam lines is returned to the boilers by a Holly gravity-return system. All steam- and hot-water piping is covered with 85 per cent. magnesia sectional covering. Removable-flange and valve covers are provided on the high-pressure steam piping so that any joint or valve may be inspected or repaired without injury to the covering. All pipe lines are painted with a distinctive color for each system so that they may be readily identified.

As coal is supplied by railroad, a reserve supply is needed and this is taken care of by outside storage. The N. Y., N. H. & H. R.R. tracks are adjacent to the power-plant property and a siding is provided for the power

plant. Coal is received in hopper-bottom cars and dumped into a hopper under the siding. From this hopper it is crushed and elevated to a pile on the ground, from which it is picked up by a grab bucket worked from an overhead monorail hoist and distributed either to the storage area or to the coal bunkers. The monorail structure, Fig. 2, consists of three sections of 20-in. I-beams supported by a steel structure so arranged that all available property may be used for coal storage. The sections of the monorail are joined to a monorail over the bunker by a three-way switch so that coal may be taken from any part of the storage directly to the bunker. The monorail

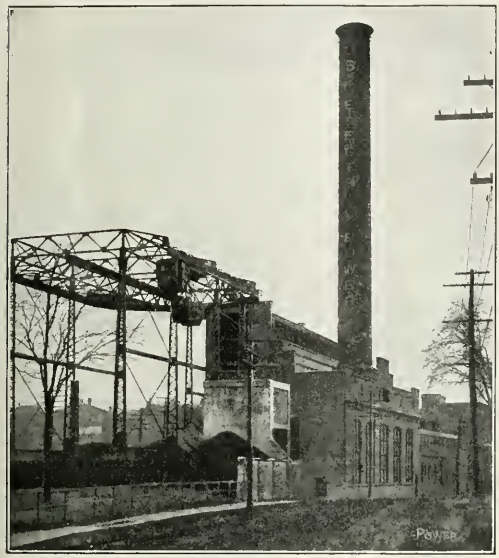


FIG. 2. MONORAIL STRUCTURE AND POWER PLANT

hoist has two 5-hp. trolley motors and two 37-hp. hoist motors. The grab bucket used is a 1⅝-yd. clam-shell type, digging bucket. The monorail beams are 50 ft. above the ground level. The hoist has a travel speed of 300 ft. per min. and a hoisting speed of 100 ft. per min. Between 25 and 30 tons of coal can be taken from the storage to the bunker per hour. From the bunker the coal is fed to the stokers through spouts.

Ashes from the stokers are discharged into concrete ash hoppers and then into cradle dump cars. The cars are manually wheeled to the end of the plant and dumped into a pit underneath the monorail. The same monorail grab-bucket hoist that handles coal takes the ashes from this pit to a concrete ash-storage bin in the yard under one of the monorails and from this bin ashes are loaded into trucks by gravity and carted away.

The generating equipment of this station consists of 350 kw. direct current in engine-driven units and 3000 kw. alternating current in turbine-driven units. The recently installed generating unit is a 1500-kw. bleeder Westinghouse turbine-driven set. The bleeder connection of this turbine was left out and a connection from the auxiliary exhaust-steam lines is installed so that any excess exhaust steam not used for heating feed water, may be used in the low-pressure stage of the turbine.

Directly under the turbine is placed a LeBlanc jet condenser. The only available condensing water in Meriden is a small brook which at times runs very low and hence supplies enough condensing water for only about half of the time. To take care of the cooling water at times of low water in the brook, a Wheeler-Barnard forced-draft cooling tower is installed. The power for the fans of cooling tower is furnished by a 30-hp. motor belted to the fan shaft. The piping from the condenser is arranged so that water may be used either from the brook or from the cooling tower. The cooling tower is designed to cool sufficient condensing water to give a 27-in. vacuum at the least favorable atmospheric conditions likely to occur.

The switching equipment for this station is of remote-control, mechanically operated oil-switch type with non-automatic oil circuit-breakers on the generators and automatic circuit-breaker on the feeders. The current is generated at 2200 volts, 60 cycles, two-phase, and excitation is furnished by either a 25-kw., turbine-driven or by a 25-kw., motor-driven exciter set.

The lighting and power for station use is taken from separate transformers connected to the main bus by a common oil switch. The lighting is a 220-110-volt tungsten system.

Provision has been made in both building and equipment to permit of future extension as the load increases, and on available property there is sufficient space to take care of the load for many years with the present rate of increase.

The extension of this plant was carried on while the

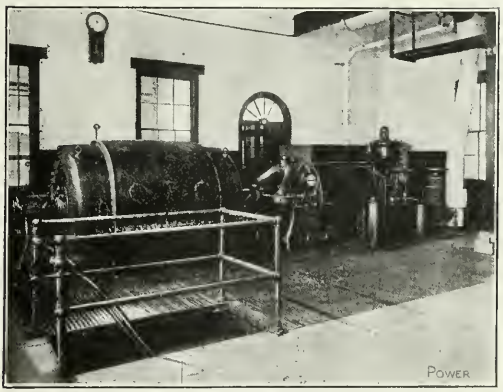


FIG. 3. ONE OF THE TURBINE UNITS

plant was in regular service. Westinghouse, Church, Kerr & Co. were engineers for the entire work and installed the apparatus.

✲

Earnings from water power generated by the hydro-electric station forming part of the Wachusett dam of the Metropolitan Water Board of Massachusetts amounted to a net sum of $21,470 for the year 1912, according to Chief Engineer Dexter Brackett's annual report. The total quantity of energy generated was 5,741,588 kw.-hours and 26,393,100,000 gal. of water under an average effective head of 90.8 ft. were used. The gross receipts from the sale of power were $30,465.66, and the cost of operating the station was $8,995.66, including an item of $2675 for taxes. The net earnings per 1000 kw.-hours generated were $3.74 Nearly all of the current was delivered to the Connecticut River Transmission Co. under a five-year contract which went into effect on Oct. 2, 1911.

Low-Pressure Steam Turbines*

By Jerome Strauss

SYNOPSIS—The economic advantages of low-pressure steam turbines and their applications are described with tabulations of costs of power in existing plants before and after being equipped with low-pressure steam turbines, and costs of different types of plants are compared.

When first put into service, the purpose of the low-pressure steam turbine was merely to recover to some extent the large amount of energy discarded when piston engines exhaust into the atmosphere, particularly for intermittently operated units where the use of condensing apparatus would be unwarranted. But its field of usefulness has been broadened.

Operative Advantages

The ability of the low-pressure turbine to utilize energy of exhaust steam more efficiently than a reciprocating engine, or the latter's equivalent in the form of an additional cylinder to the original engine, is readily comprehended. In the piston engine, the condensation and re-evaporation on the cylinder walls due to temperature changes during the cycle is very large; this is so much wasted energy. In the turbine there are no cyclic changes; in each part of the unit the physical condition of the steam remains reasonably steady, thus yielding a constant temperature and avoiding the above losses. Again, due to the high velocities employed in turbine form of construction, the large volumes of steam encountered when working in the lower pressure ranges present no difficulties, for only small areas are then necessary. But in the engine the mechanical friction and also high cost of the enormous cylinders required to accommodate these volumes are prohibitive. For this reason the condensing engine must use a relatively small cylinder, release the steam when it has given up only a portion of its available energy and discharge the rest into the condenser. Thus, since the piston engine utilizes the higher pressure ranges with greatest efficiency and the turbine acts similarly with low-pressure steam, evidently from the water-rate viewpoint, the best arrangement for the complete range is a combination of the two.

General Application

Coming to a consideration of improvements in existing steam plants, there are two general classes of service to which the low-pressure turbine may be applied.

(a) Intermittent and widely varying exhaust-steam supply; these conditions obtain in rolling-mill engines, steam hammers, mine-hoisting machinery, etc.

(b) Continuous exhaust-steam supply which may or may not be uniform; in this class are included central power stations for lighting, traction or factory drive.

In rolling mills and in mines it is unquestionably preferable to retain the old piston engines and use their exhaust for the production of electricity rather than purchase entirely new installations consisting of high-pressure turbines generating electric current for use in reversible motors to replace the engines, as has been suggested. With the latter arrangement to obtain one horsepower at the motors would require from 27 to 30 lb. of steam per hr., whereas, by combining the reversing reciprocating engines as they stand with low-pressure turbines, the same results may be had for an expenditure of 17 to 18 lb. Besides, the great difference in initial cost should be sufficient to bar the use of the high-pressure turbine and reversible-motor system, for the economy of the engine-turbine combination arises not solely from the saving in coal but also from the low cost of installation; the only expense is the price of the turbo-generator set, its accumulator and condenser, and the space required is so small as usually to permit setting the new unit in the existing engine room. In fact, in a mine working 10 hr. a day, the economy is usually sufficient to pay for the initial expenditure in two or three years, while in steel mills operating day and night, this time reduces to one and one-half years or less.

TABLE 1. COLLIERY ECONOMIES

No.	Orizinal Output I.hp.	Steam Consumption Lb. per hr.	Final Output Eng. I.hp.	Final Output Turbine Equiv. I.hp.	Final Output Total I.hp.	Additional Output %	Additional Steam Lb. per hr.	Additional Steam %	Steam Consumption per I.hp. Original	Steam Consumption per I.hp. Turbine Only	Steam Consumption per I.hp. Overall (Final)	% Reduction
1	1100	14,500	700	400	1100	None	—2800	—19 3	13 2	29.3	10 6	19.3
2	1100	14,500	1000	750	1750	60	3000	20.7	13 2	23 4	10.0	24 5
3	1000	15,000	800	600	1400	40	None	.	15 0	25 0	11 0	27 0
4	1600	25,000	1400	1100	2500	56	2400	9 4	16.0	25 4	11 2	30 0
5	870	12,500	640	500	1140	32	None	.	14 4	25 0	11 0	24 0
6	870	12,500	870	655	1525	75	4000	32 0	14 4	25 2	10 8	25 0
7	1550	20,000	1125	675	1800	16	—3500	—17 5	13 0	24 5	9 2	29 0

The series of results given in Table 1 were presented by J. Burnes in a paper before the Institute of Mining Engineers at Nottingham, England, in September, 1910. The savings shown, being on the average 25.5 per cent., are remarkable, representing, as they do, betterments of the engine-turbine combination over colliery engines operating originally condensing.

When the supply of exhaust steam from the existing plant is uniform the turbine problem simplifies. The regenerator or accumulator is no longer necessary; thus one expense item is eliminated. Then there are several different ways in which engine and turbine can operate together, enabling a variety of conditions to be satisfied.

Systems of Operation

In any constantly operated unit consisting of piston engine and low-pressure turbine, two general systems of linking the component parts are recognized:

(a) Operation with variable intermediate pressure.

(b) Operation with constant intermediate pressure.

The low-pressure turbine can advantageously be applied in any case where piston engines are now in use. Their installation will always yield a marked improvement in operating economy without additions to the boiler plant, this economy being greatest when the back pressure on the engine is permitted to vary. Where ap-

*Abstract of paper entitled "Advantages and Applications of the Low-Pressure Steam Turbine," for which the author was awarded the "Stillman Prize in Applied Technology," open to competition by members of the class of 1913, Stevens Institute of Technology.

plicable the variable intermediate pressure system recommends itself not only because it permits adjustment of the engine back pressure to maintain the greatest overall economy but also as in all but one case no intermediate governor is necessary. All regulation is taken care of by the piston-engine governor; an overspeed stop is placed on the turbine, but this is necessary in all turbine practice.

This no-governor system is advantageous for all cases in which the loads on the engine and turbine vary together, both units supplying the same immediate system. The tie may be electrical as in lighting or traction stations, or mechanical as in the textile mills of New England. In the former case the two generators, one direct connected to each unit, send their power to the same busbars and operate in parallel. It may thus be said that the turbine merely "floats" on the system, its speed being under definite control due to the fact that the voltage of the two generators must be equal. If the turbine speed increases slightly it will take more load, thus causing the engine load to decrease, resulting in earlier cutoff. The engine then supplies less steam to the turbine, the latter slows down and the load relations return to their original condition. In practice these surgings of the load are so small as to be scarcely noticeable. These are the circumstances in direct-current stations. For alternating-current operation, the synchronizing force of the alternators is sufficient to maintain equal speed and hence the proper load proportions.

In mills it is usual to find a large proportion of the engine exhaust utilized for heating and manufacturing purposes. Here it is customary to install turbines large enough to consume the maximum available steam supply, so as to prevent any possible waste of steam. The absence of the above type of electrical control was puzzling for a time, but the difficulty was readily overcome. The scheme employed is to have the turbine drive a synchronous generator which operates in parallel with a synchronous motor belted to the main shaft. If the engine becomes overloaded and the turbine draws more than the normal amount of steam the increased energy that the turbo-unit generates would be transmitted to the main shaft by the motor. Thus the load on the engine and the quantity of steam necessary for operation would decrease and normal conditions would reappear. This system applies equally as well whether the turbine load is all mechanical or both mechanical and electrical.

When constant load on the piston engine is required, coincident with the maximum economy (which, as seen, is due to operation with variable intermediate pressure) a slightly more complicated system is used. These conditions obtain usually in central stations supplying substations in both business centers and in suburban districts. Here the main engine is constantly loaded, the turbines carrying a varying load; at the same time very economical operation is essential. In this system a governor is placed immediately before the turbine, and is arranged to bypass part of the steam to the condenser when the turbine load is light. When the turbine does not need all the engine exhaust to supply its demands, the main engine is allowed to operate on a decreased back pressure. As the engine takes a constant load, this action will cause a reduction of overall total steam consumption, thus maintaining maximum economy.

When the load on the main engine is approximately constant a system employing constant intermediate pressure may be used. Here a simple constant-pressure valve forms the governor. Of course, in this case the economic results are slightly poorer than without the governor, approximating 2 to 5 per cent. increase in water rate. But where constant engine load is a necessity, this does not constitute an objection, as it is counterbalanced by the extra cost and complexity of the bypass system. With this method of combination, a live-steam admission valve should be provided for use in emergencies. Plants requiring such installations as the one here described usually carry a rather high load factor. It is advantageous to have the turbine take care of the peaks and in general all of the more unfavorable load conditions. This latter it is well capable of doing; in fact, the casting of these unfavorable conditions on the turbine usually gives greater overall efficiency than that found with unfavorable piston-engine conditions as the turbine is less sensitive.

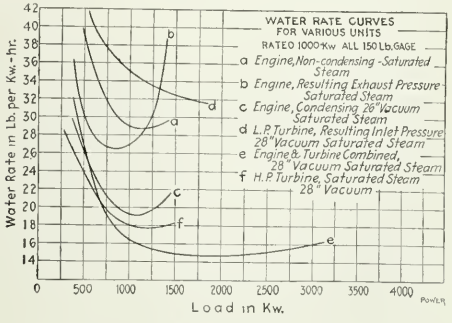

WATER RATE CURVES
FOR VARIOUS UNITS
RATED 1000 Kw ALL 150 Lb. GAGE
a Engine, Non-condensing - Saturated Steam
b Engine, Resulting Exhaust Pressure - Saturated Steam
c Engine, Condensing 28" Vacuum - Saturated Steam
d L.P. Turbine, Resulting Inlet Pressure 28" Vacuum Saturated Steam
e Engine & Turbine Combined, 28" Vacuum Saturated Steam
f H.P. Turbine, Saturated Steam 28" Vacuum
Water Rate in Lb. per Kw.-hr.
Load in Kw.
POWER

FIG. 1. RELATIVE ECONOMIES

APPLICATION TO EXISTING PLANTS

The special applications of the exhaust turbine to existing plants yielding uniform exhaust-steam supply for use in the turbine are three in number:

(1) Good engine design; fair operating efficiency; increase in capacity necessary.

(2) Inefficient or costly plant operation; condensing or noncondensing engines; increase in economy desired; capacity a secondary consideration.

(3) Plant location poor; water-supply troubles; enforced noncondensing operation since gain with the same engine condensing would not pay.

The first case is the one most frequently encountered and deserves careful investigation. In any fairly efficient reciprocating-engine plant where a capacity increase is desired, three possible solutions present themselves:

(a) Installing additional reciprocating engines of the same type, operating under the same conditions.

(b) Applying the more efficient complete-expansion turbines.

(c) Adding a low-pressure turbine which will increase the efficiency as well as the economy.

The result of these methods on the steam consumption and hence fuel economy are illustrated in Fig. 1. Here the steam pressure on all units is 150 lb. gage. The curves shown have been prepared to represent average operating conditions and not the fanciful results of tests.

The truth of this statement will undoubtedly be clear from the fact that tests have given a steam consumption for the engine-turbine combination of from 13 to 13.5 lb. per kw.-hr., whereas in the chart shown it is considered that in the average plant under actual operating conditions, good results at full load will show 15.6 lb. per kw.-hr. Also in the case of the turbines a vacuum of 28 in., on a basis of 30 in. as absolute zero pressure, has been taken; with the engine, however, 26 in. has been used for the comparison because, in the everyday working of a piston engine, the opportunities for air leakage are so great and condensation losses so much increased by higher vacua that it seldom is worth the extra expense to reduce the back pressure below 2 lb. absolute. In examining the curves of Fig. 1 it must be remembered that the addition of the low-pressure turbine is the only method that would increase the power generated without increase in the original total quantity of steam, all others necessitating additional boiler capacity. With this in

TABLE 2. COST OF POWER PER KW PLANT RATING—2000 TO 5000 KW.

Authority	Reciprocating Engine Condensing Initial Cost	Reciprocating Engine Condensing Yearly Expense	High-Pressure Steam Turbine Initial Cost	High-Pressure Steam Turbine Yearly Expense	Reciprocating Engine and Low-Pres. Turbine Initial Cost	Reciprocating Engine and Low-Pres. Turbine Yearly Expense	Gas Engine Producer Gas Initial Cost	Gas Engine Producer Gas Yearly Expense
Townley	100 00	30 10						
Webber	77 20	26 10						
Phila. St. Ry.	100 00				82 60			
Moses	95 00		90 00				110 00	
Weston	94 20	30 45					132 00	27 80
Andrews	87 00				75 85	26 80	118 20	30 50
Hand	102 10						108 30	
Collins			61 50	22 60	59 20	21 75		
Frye (Dixon)	87 40		78 75					
Knowlton		29 80						
Mistek	91 00	33 20						
Cleghorn							113 40	32 40
Kapp					87 20	28 15		
Wilson	95 00	31 65	78 50	28 90				
Streeter							117 00	
Moore	104 00	32 70						
Moore	94 30	30 60						
Gebhardt		33 75				27 05		
Eng. Rec.			97 60	30 20				
Burns					73 90	26 55	114 85	29 40
Dunham	79 50	29 70						28 80
Kershow		32 45						
Porter			88 30	27 50				
Snow	76 90	25 60						
N.E.L.A.							126 00	
Beardsley			75 40					
Fox		36 20						
Chance					83 80	26 00	110 80	28 70
Hutton	75 35		72 90					
Newington					67 60	23 15		
Average	90 60	30 95	80 35	27 30	75 70	25 70	116 70	29 60

mind, it is evident that none of the combinations shown could possibly yield a water rate below that of the engine-turbine combination. A new installation of turbines with reasonable superheat will not obtain as good an economy. A turbine with high superheat and a very high vacuum (29½ in.) or a reciprocating engine, such as the Sulzer, using a superheat of 200 to 300 deg. F., and a high vacuum will no doubt have a steam consumption equal to that of the engine-turbine unit, but a comparison of the initial cost of such machinery with that of the exhaust turbine, and the additional careful attendance necessary for these economical single units explains the reason for not adopting them here.

If superheaters are added to the boilers, the water rate of the engine-turbine unit will also show a marked decrease.

There remains one more valuable fact which is evident from an examination of these curves: the engine-turbine combination is efficient over a wide range of load, its water rate curve very closely approaching a straight line within the usual operating limits. Indeed, at half load, when the condensing engine or high-pressure turbine has increased its steam consumption to almost 30 per cent. more than the consumption at full load, the corresponding change for the engine-turbine unit is only 13 per cent. On overload the high-pressure turbine shows an increase only slightly greater than that of the combined unit, but the condensing-engine water rate rises with extreme rapidity.

Comparison with High-Pressure Turbines

It is generally conceded that the engine-turbine installation, without buildings, requires an expenditure slightly less or at the maximum, equal to that for the high-pressure turbine plant. But it has been erroneously maintained that the building for the turbine would be smaller than that necessary for the combination. It is quite true that the turbine alone requires less engine-room floor space. However, the larger water rate of the turbine means additional boiler and condenser capacity, and this increase is sufficient to cause the buildings for the high-pressure turbine and for the engine-turbine unit to be of equal size. The installation cost will, therefore, be slightly in favor of the low-pressure turbine. Fixed charges at the same rate on a smaller investment and a considerable decrease in fuel consumption, due to a smaller water rate, will more than counterbalance the small increase in the cost of oil, waste and a possible slightly larger cost of attendance; hence the total yearly cost also will recommend the exhaust steam-turbine installation.

Comparison with Internal-Combustion Engines

The low-pressure turbine can compete advantageously with the internal-combustion engine. The former is more simple, responsive and dependable; in addition it costs less. Roughly, the initial cost of the engine-turbine plant is 60 to 70 per cent. of that of the gas-engine station. By using the maximum available amount of energy in the steam the fuel consumption is only a little greater than that necessary in the gas engine. In the latter type of installation, the rate of fixed charges is greater, due to the larger percentage reserve necessary to cover depreciation, and also the increased outlay for repairs. Hence a larger percentage of fixed charges on a much larger initial cost will cause the yearly expenses of the gas-engine plant to exceed those of the engine-turbine steam plant. Also the spares in a producer-gas installation are never necessary in the steam plant. It is understood, however, that these are economic considerations for the general case only. In special instances, as when it is desired to eliminate smoke, or where fuel of a poor quality only is available, as in peat districts, the gas engine will strongly recommend itself. But with anthracite of reasonably good quality, and the ordinary plant location, the above considerations do not favor the gas engine.

Costs by Various Systems Compared

Contrary to the preceding deductions many men of recognized authority in the engineering profession have maintained that the engine-turbine combination, new, is not as advantageous as certain other systems (high-pressure turbine in particular), owing to the great investment cost and likewise expense of operating attendance and supplies. They have declared that all new installations will be straight steam-turbine plants. To determine the validity of these arguments, the accompanying Table 2 was prepared.

It contains the initial cost (exclusive of land) and the yearly cost in dollars per kilowatt of rating for various kinds of plants, having a rated output of 2000 to 5000 kw. The hydraulic power station has been omitted as such modes of generation are feasible only in a certain few localities. Plants in which the prime movers are oil engines and those employing a combination of gas engines with high-pressure turbines have not been tabulated because a sufficient quantity of representative, reliable data were not obtainable. Those types of installations shown are the most common and most important ones and are all that are necessary for the present investigation.

As the data taken from different sources were obtained under various conditions, in compiling the table, it was necessary to assume a set of conditions as near as possible to those under which the major portion of the available data was taken, and to provide means for reducing other data to the assumed basis. Where there was too much variation from assumed conditions the data were discarded.

The assumption of conditions and also means of reduction are best shown tabulated:

(a) Plant operating 3000 hr. per year.

(b) Curve-load factor 60 per cent.

(c) Coal at $3 per ton delivered.

(d) Where cost of building was not included, value was taken as the average of those values contained in lists of costs of the other plants of the same type.

(e) When only operating costs were given, fixed charges were obtained from average price of plant as given by the other figures.

(f) Fixed charges, such as above computed, with these values: Steam plant, 13 per cent., gas plant, 15 per cent. This includes interest, depreciation, insurance and taxes, also 2 per cent. repairs on steam plant and 2.5 per cent. on gas plant.

(g) Engine efficiency (mechanical), 93 per cent.

(h) Generator efficiency, 97 per cent.

It is difficult to make any decision as to the type of installation to be employed without a knowledge of the controlling features for the particular problem. For present purposes, peculiarities of real estate and location cannot be considered. But for the general case of a plant of the size taken for this table, the combined opinion of those quoted indicates that the engine-turbine combination has both initial cost and yearly expense in its favor. The values given have not been largely matters of computation for the results from actual installations appear far more frequently than engineers' estimates.

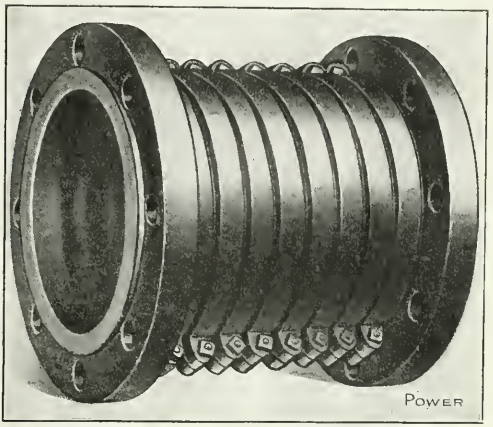
The production of results that often exceeded the guarantees (striking in themselves) of the manufacturers and the expectations of the purchasers has contributed greatly to the success of the exhaust-steam turbine. The rapid growth of its adoption in general, has been remarkable. The first installation on a commercial basis was begun in the Mines de la Bruay, in France, by Professor Rateau in 1901 and completed in 1902. In 1907 the Rateau turbine and regenerator were introduced in America, the first installation being at the Irondale steel works of the International Harvester Co. Its success was immediate and conclusive, and within a brief period steel mills in various parts of the country had adopted it. Then came the application to central stations and industrial establishments at such a rate that in seven years, hundreds of plants have been equipped with these prime movers.

Badger Self-Equalizing Expansion Joint

Probably every engineer has had experience with the strains in pipe lines caused by expansion and contraction. Loose, leaky fittings and perhaps here and there a fractured joint point conclusively to the necessity for some device having sufficient flexibility to absorb these changes in length. The engineer also knows that the amount of change in pipe length depends upon two factors, the length of the pipe and the difference in temperature.

The Badger self-equalizing expansion joint, illustrated herewith, is a corrugated copper joint having external rings. It is designed to take up changes in length in pipe lines, whether these pipe lines convey steam, water or air.

The joint combines the elasticity to stand repeated changes of shape with strength to resist any pressure for which it is designed. The corrugated form, such as used for furnaces of internally fired marine boilers is



BADGER EXPANSION JOINT

adopted because of its strength and flexibility. But a single piece of copper would have to be very thick for high pressures, and in actual practice it is found that there is always a tendency for one or two corrugations to take the entire strain of repeated change in shape. In time, those few corrugations, taking all the work, would give out.

External rings on the corrugations of the Badger joint distribute the strains among several corrugations and by thus bringing many corrugations into service no one of them takes more than its share of work. The external rings force a part of the strain to the next corrugation and as each corrugation has but slight movement the joint should last almost indefinitely. The external rings give added strength to the joint in the same way that spiral winding of a pipe with wire adds to its strength.

The number of corrugations depend upon the pressure and upon the length of the joint. For high pressures and superheated steam the change in length is considerable, therefore, more corrugations are used. For very low pressures, as in exhaust piping, two or three corrugations are sufficient for the slight alteration in length. There are even some cases where the expansion is so little that the

joint does not need any external rings. But in most cases external rings are used both to add strength for high pressure and also to stiffen the exhaust pipe against collapse.

The Badger expansion joint, which is made by the E. B. Badger & Sons Co., 63 to 75 Pitts St., Boston, Mass., is made in a complete line of sizes for all pressures and with flanges drilled to A. S. M. E. standards, both high-pressure and extra-heavy pressure. These joints require no packing and take up no more room than a pipe of the same diameter. The joint can be made oval, rectangular, circular and in other special forms.

The Analysis of Boiler Losses

By John G. Moxey

SYNOPSIS—How to determine the actual heat distribution from the time the coal is fired to the boiler until it has been consumed and has passed off to the stack.

Having given the chemical or ultimate analysis of the coal used in the evaporative test, Dulong's formula may be used to determine the heat value, which is equal in British thermal units per pound to

$$14{,}600\,C + 62{,}000\left(H - \frac{O}{8}\right) + 4000\,S$$

where C, H, O and S are proportionate parts by weight of the carbon, hydrogen, oxygen and sulphur, respectively, present in the coal. The efficiency of boilers ranges from 50 or less to 80 per cent., and in some rare cases even higher. The difference between the efficiency actually obtained and the ideal efficiency of 100 per cent. represents the heat lost while converting the heat energy stored in the coal into that contained in the steam within the boiler. This loss is made up of several items, as follows:

1. The loss of fuel through the grates, being present in the ash as unburned coal.

2. Unburned fuel carried beyond the bridge-wall in the form of soot or small particles which go to form smoke.

3. The loss due to the amount of heat necessary to raise the temperature of the moisture in the coal from that of the boiler room to the boiling point, 212 deg. F., to evaporate that moisture at this temperature and superheat the steam thus formed to the flue-gas temperature.

4. The loss due to the presence of hydrogen in the fuel which, uniting with the oxygen of the air, forms water which in its turn, it is assumed, must be evaporated and superheated, as in item 3.

5. Superheating the moisture in the air supplied from the prevailing atmospheric temperature to that of the flue gases.

6. Heating the products of combustion to the flue-gas temperature.

7. The loss due to the incomplete combustion of the coal when the carbon C burns to carbon monoxide CO only instead of to carbon dioxide CO_2, plus the loss due to volatile matter passing off unburned.

8. The loss due to radiation of heat from the boiler and furnace. It would require an elaborate test to ascertain each one of these items of loss and in good practice it is customary to summarize them as follows:

(a) The loss due to moisture in the coal. This loss may be ascertained by the formula:

$$(9H + W)\,[212 - t + 970.4 + 0.48\,(T - 212)]$$

in which H and W are the proportionate parts, referred to the combustible, of the hydrogen and water respectively present: t is the boiler-room temperature, T the temperature of the flue gases, 9 is the ratio in weight between hydrogen and water (based on the atomic weights), 212 is the boiling point, 970.4 is the latent heat of the steam at 212 deg. F. and 0.48 is the specific heat of steam at constant pressure.

(b) The loss due to the heat carried off in the flue gases, which is equal in British thermal units to

$$0.24\,(T - t) \times \textit{wt. of gas per lb. of combustible}$$

where 0.24 is the mean specific heat of the chimney gases and T and t have the same significance as before.

(c) The loss due to the incomplete combustion of carbon forming CO instead of CO_2. This is equal in British thermal units to

$$C\frac{10{,}150\,CO}{(CO_2 + CO)}$$

in which 10,150 is the actual loss in British thermal units per pound in having the carbon burn to CO instead of CO_2, CO and CO_2 are the percentages by volume of those compounds present in the flue gas, and C the proportionate part by weight of the carbon in the combustible.

(d) The heat unaccounted for, which is equal to the total heat generated less the sum of that utilized in forming steam in the boiler and the losses (a), (b) and (c). This unaccounted for loss is included under items 2, 5 and 8, and the loss arising from the unconsumed gases.

A schedule of these heat expenditures is called a heat balance. To make it requires an evaporative test of the boiler, an analysis of the flue gases, an ultimate analysis of the coal and refuse, and a calorimeter determination of the heat value of the coal.

To illustrate the practical application of the foregoing the following data from a recent test of a 650-hp. water-tube boiler may be used:

Average steam pressure, lb. per sq.in.		185
Temperature of stack gases, deg. F.		570
Temperature of boiler room, deg. F.		81
Temperature of feed water, deg. F.		171
Humidity in the air, per cent		96
Weight of dry coal fired, lb. per hr.		3,330
Moisture in the combustible, per cent		1 46
Ash or refuse in wet coal, per cent		7 87
Combustible in ash or refuse, per cent		21 10
Calorific value of coal, B.t.u. per lb.		14,100
Actual evaporation, lb. of water per hr		31,611 5
Superheat in steam, deg. F		40
Factor of evaporation		1 114
Analysis of Dry Coal*		
Carbon, per cent.		75 92
Hydrogen, per cent.		5 21
Oxygen, per cent.		4 22
Nitrogen, per cent.		1 28
Sulphur, per cent.		1 70
Ash, per cent.		8 86
Volumetric Analysis of Flue Gases		
Carbon dioxide, per cent.		9 800
Oxygen, per cent.		8 887
Hydrogen, per cent.		0 400
Carbon monoxide, per cent.		0.300
Nitrogen, per cent.		80 613

*These percentages usually total 100, and should in this case, as later in the article the ash and nitrogen are deducted from 100 to get the percentage of combustible in the coal.—Ed.

The heat balance may now be obtained. The loss due to moisture in the coal together with that due to the hydrogen is:

$$(9H + W)\ [212 - t + 970.4 + 0.48\ (T - 212)]$$
$$= (9 \times 0.0521 + 0.0146)\ [212 - 81 + 970.4 + 0.48\ (570 - 212)] = 615.61\ B.t.u.$$

per lb. of combustible fired.

To compute the loss of heat in the dry chimney gases per pound of combustible fired, the weight of the gases must first be ascertained. The air supplied per pound of combustible is gotten from the flue-gas analysis as follows:

			O	C
CO_2 9.80	$\times 0.1235 =$ 1.2103	$\times \frac{8}{11} =$	0.8802	0.3301
CO 0.30	$\times 0.0781 =$ 0.0234	$\times \frac{4}{7} =$	0.0134	0.0100
O 8.887	$\times 0.0893 =$ 0.7936	$\times 1 =$	0.7936	
			1.6872	0.3401

Where the second figure in each equation is the density,

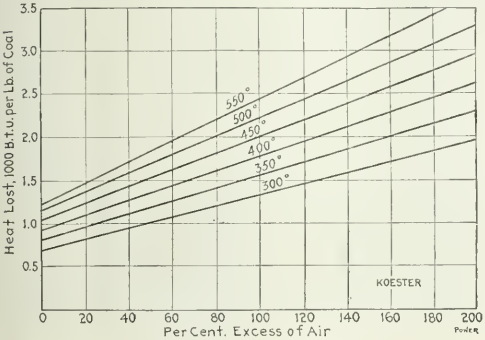


FIG. 1. HEAT CARRIED OFF BY GASES

or weight in pounds per cubic foot, of the gas in question. One pound of carbon dioxide, CO_2, is composed of

$$\frac{2 \times 16}{12 + (2 \times 16)} = \frac{8}{11}\ lb.$$

of oxygen and the remaining $\frac{3}{11}$ lb. of carbon. A pound of carbon monoxide, CO, is composed of

$$\frac{16}{12 + 16} = \frac{4}{7}\ lb.$$

of oxygen and $\frac{3}{7}$ lb. of carbon, where 16 and 12 are the atomic weights of oxygen and carbon, respectively.

$$\frac{1.6872}{0.3401} = 4.96$$

$$\frac{4.96}{0.232} = 21.38\ lb.\ air\ per\ lb.\ carbon$$

as air contains 23.2 per cent. oxygen by weight. The air to burn the carbon in 1 lb. of coal of the composition given in the analysis would be

$$21.38 \times 0.7592 = 16.23\ lb.$$

The air to burn the hydrogen in 1 lb. of coal would be

$$36\left(0.0521 - \frac{0.0422}{8}\right) = 1.68\ lb.$$

Then per pound of coal

$$16.23 + 1.68 = 17.91\ lb.$$

of air would be required, and per pound of combustible

$$\frac{17.91}{0.8986} = 19.93\ lb.\ of\ air$$

or 20.93 lb. of flue gas. The heat loss in the flue gases may be found by multiplying the pounds of gas by the temperature rise and the specific heat of the gases.

$$20.93\ (570 - 81)\ 0.24 = 2156\ B.t.u.\ per\ lb.\ combustible$$

The curves in Fig. 1 clearly show the amount of heat carried off by the chimney gases for different temperatures and varying amounts of air fed to the boiler.

From the ultimate analysis of the coal the per cent. of carbon in the combustible is

$$\frac{0.7592}{1.00 - (0.013 + 0.0886)} = 0.845 = 84.5\ per\ cent.$$

Then the loss per pound of combustible due to incomplete combustion is

$$C\frac{10,150\ CO}{(CO_2 + CO)} = 0.845\frac{10,150 \times 0.003}{0.098 + 0.003} = 254.75\ B.t.u.$$

As has been said previously, this so called incomplete combustion is caused by the gases passing off as carbon monoxide instead of carbon dioxide. The next illustra-

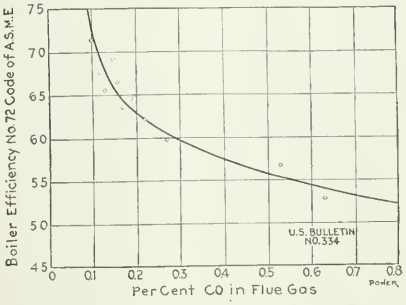


FIG. 2. RELATION OF AVERAGE CO TO BOILER EFFICIENCY

tion, Fig. 2, taken from some recent tests conducted by the government shows how this apparently small item may sometimes appreciably affect the general economic operation of a boiler. These tests also point out what has already been claimed, that should the carbon dioxide vary much below 13 per cent. or thereabouts the efficiency of the boiler is greatly reduced.

The heat absorbed by the boiler is found by determining the water evaporated per pound of combustible and getting the equivalent heat value.

Since 3330 lb. of dry coal is fired per hour and the coal contains 89.86 per cent. combustible there is fired 2995 lb. of combustible per hour. Now the actual evaporation is 31,611.5 lb. of water per hour, which, with a factor of evaporation of 1.114, gives

$$31,611.5 \times 1.114 = 35,215\ lb.$$

of water from and at 212 deg. F. per hr., or

$$\frac{35,215}{2995} = 11.76\ lb.$$

of water evaporated from and at 212 deg. F. per lb. is absorbed per pound of combustible.

$$11.76 \times 970.1 = 11,412\ B.t.u.$$

are absorbed per pound of combustible.

The loss through the grate was found to be 7.87 per cent. of the wet coal, which refuse contained 21.1 per cent. of combustible. Then

$$0.211 \times 0.0787 = 0.0166 = 1.66\ per\ cent.$$

of wet coal was lost through the grate, or 1.495 per cent. combustible, which per pound amounted to

$$15{,}660 \times 0.01495 = 234 \ B.t.u.$$

It was found that 19.42 lb. of air were being fed to the boiler per pound of combustible while the prevailing atmospheric humidity was 96 per cent., which for air at 81 deg. F. gives

$$0.96 \times 0.0236 = 0.02265 \ lb.$$

water in 1 lb. of air fed to the boiler, the number 0.0236 being the weight of vapor mixed with 1 lb. of air at 81 deg. F. This amounts to

$$19.42 \times 0.02265 = 0.44 \ lb.$$

of water in the air fed to the boiler per pound of combustible fired. The heat lost, therefore, due to humidity is

$$0.44 \times 1.355 \times 970.4 = 579 \ B.t.u.$$

per pound of combustible; 1.355 is the factor of evaporation when evaporating water at 81 deg. F., the boiler-room temperature, and superheating it to 570 deg. F., the flue-gas temperature, at atmospheric pressure.

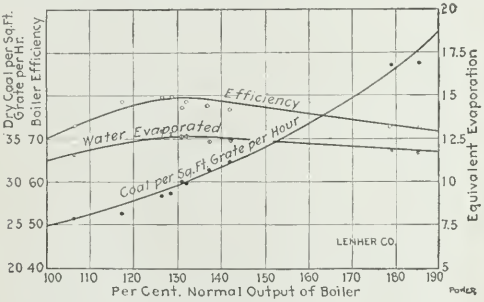


FIG. 3. CURVES FROM BOILER WITH UNDERFEED STOKER

The results may then be grouped as in the accompanying table.

HEAT BALANCE—TOTAL HEAT IN 1 LB. COMBUSTIBLE, 15,660 B.T.U.

Distribution of Heat	B.t.u.	Per cent.
Heat absorbed by boiler	11,420	72.93
Loss due to moisture in coal and moisture formed by burning hydrogen in coal	615.61	3.93
Loss in chimney gases	2,456	15.68
Loss due to incomplete combustion	254.75	1.63
Unaccounted for losses:		
Through grate	234	1.49
Humidity	579	3.70
Other items, as unburned fuel passing beyond bridge-wall, smoke, radiation, leakage, etc.	100.64	0.64
Total	15,660.00	100.00

The accompanying table shows how close the heat balance may be made, although it must be said that the unaccounted for losses usually total as high as 3 to 5 per cent.

Fig. 3 is given as a good example of boiler operation. This boiler was equipped with an underfeed stoker of the latest design and gave an exceedingly high economy, one test in which the CO_2 content by volume was 13 per cent. giving a total efficiency of boiler and grate of 79.8 per cent. The oxygen present in the flue gas was 6.2 per cent. with no traces of CO. The flame of this underfeed stoker is very short, rarely reaching a total length of 2 ft., which is in marked contrast to a hand-fired furnace, while being pushed, when the long yellow flames envelop the tubes, and are carried well along the path of the gases.

Hirsch Electric Lamp

There are many hazardous occupations which necessitate the use of some kind of a lamp that will not cause an explosion of gases, etc. Such a lamp seems to be found in the Hirsch electric lamp which has been designed primarily for use in gaseous coal mines, but can be used to advantage by engineers about boilers, fuel-oil tanks or any place where the presence of a naked flame would be dangerous.

This 2-cp. portable lamp is supplied with current from a storage battery of 2 volts capacity, and will run the lamp for 12 hr. It requires 8 hr. to recharge the battery, which weighs 2 lb. The lamp outfit illustrated herewith

HIRSCH ELECTRIC LAMP

has received the official approval of the United States Department of Interior and Bureau of Mines to be used as a cap lamp in gaseous mines. It is made by the Hirsch Electric Mine Lamp Co., 221 to 227 North Twenty-third St., Philadelphia, Penn.

Ellis Metallic Packing

This packing is designed to be used with ammonia, steam and water. The soft, round, metallic rings, when placed in the stuffing-box, are separated by a few strands of hemp. The rings do not butt when first put in place but are separated from ½ to ¾ in. After filling the stuffing-box with rings they are forced in as hard as possible and crushed flat. After the metal rings have been flattened, a soft ring is placed next to the gland and the gland secured in position.

This packing is made by W. J. Ellis, Box 9, Lansdowne, Penn.

Chloride of calcium brine for circulation in refrigerating systems is generally made by dissolving from 3 to 5 lb. of the calcium in a gallon of water—the quantity, between the limits given, depending upon the purity of the calcium. The density of this solution is generally assumed as 23 deg. Beaume and the freezing point as nine degrees below zero.

ELECTRICAL DEPARTMENT

Primer of Electricity

By Cecil P. Poole

Wave-Connected Windings—Concluded

A peculiarity of two-path windings that is worth remembering is that if one-half the number of magnet poles be an even number, the number of armature coils must be odd; whereas if one-half the number of poles be an odd number, the number of armature coils will be odd if the commutator pitch be even, or even if the commutator pitch be odd. This rule is invariable, and it may be very helpful in rewinding or repairing old armatures. Figs. 178 and 181 illustrate the first part of the statement and Figs. 180 and 182 the second part. The first two diagrams are for four-pole windings and both have an odd number of coils. The latter two are for six-pole windings (one-half the number of magnet poles being an odd number), but Fig. 180 shows an odd number of coils and an even commutator pitch while Fig. 182 shows an even number of coils and an odd commutator pitch.

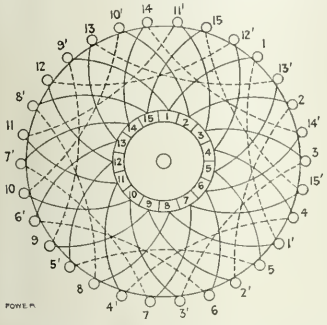


Fig. 178. Four-Pole Two-Path Winding with 15 Coils

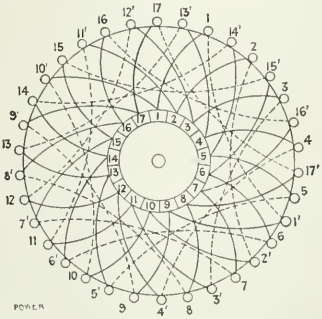


Fig. 181. Four-Pole Two-Path Winding with 17 Coils

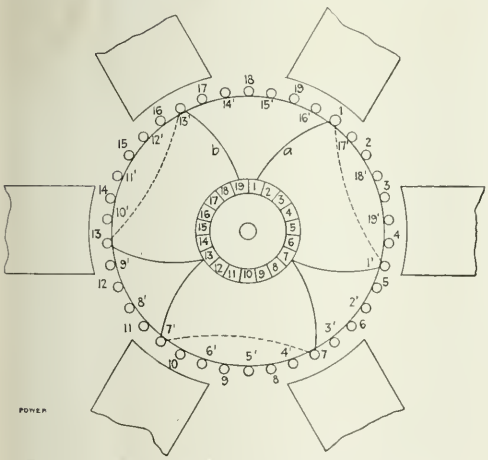


Fig. 180. Minimum Crossing, Due to Using the Larger Available Number of Coils

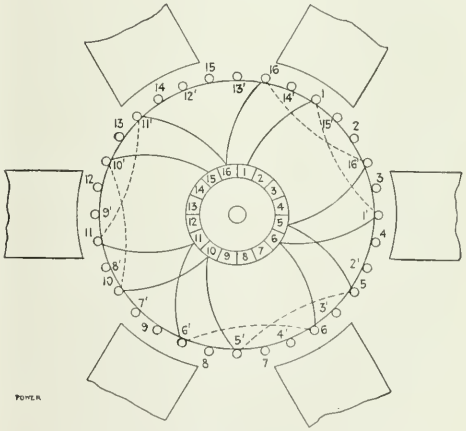


Fig. 182. Two-Path Winding with an Even Number of Coils and Odd Commutator Pitch

The accompanying tables give all of the possible combinations within a practical range, Table 8 for two-path and Table 9 for P-path wave-connected windings; P being the number of field-magnet poles. For both classes of windings two numbers of coils are available for each commutator pitch and number of poles: the larger is preferable.

In Table 8, in the four-pole column, the right-hand number in each line is two digits larger than the left-hand number. This is because half the number of poles is 2 and the number of paths is also 2; consequently, the difference between any two neighboring numbers of coils, reading either vertically or horizontally, must be 2.

These tables give, within their limits, every number

TABLE 8. RELATION BETWEEN THE NUMBER OF COILS AND THE COMMUTATOR PITCH FOR TWO-PATH ARMATURE WINDINGS

Commutator Pitch	Number of Armature Coils											
	4 Poles		6 Poles		8 Poles		10 Poles		12 Poles		14 Poles		16 Poles	
5	9 or	11	14 or	16	19 or	21	24 or	26	29 or	31	34 or	36	39 or	41
6	11 or	13	17 or	19	23 or	25	29 or	31	35 or	37	41 or	43	47 or	49
7	13 or	15	20 or	22	27 or	29	34 or	36	41 or	43	48 or	50	55 or	57
8	15 or	17	23 or	25	31 or	33	39 or	41	47 or	49	55 or	57	63 or	65
9	17 or	19	26 or	28	35 or	37	44 or	46	53 or	55	62 or	64	71 or	73
10	19 or	21	29 or	31	39 or	41	49 or	51	59 or	61	69 or	71	79 or	81
11	21 or	23	32 or	34	43 or	45	54 or	56	65 or	67	76 or	78	87 or	89
12	23 or	25	35 or	37	47 or	49	59 or	61	71 or	73	83 or	85	95 or	97
13	25 or	27	38 or	40	51 or	53	64 or	66	77 or	79	90 or	92	103 or	105
14	27 or	29	41 or	43	55 or	57	69 or	71	83 or	85	97 or	99	111 or	113
15	29 or	31	44 or	46	59 or	61	74 or	76	89 or	91	104 or	106	119 or	121
16	31 or	33	47 or	49	63 or	65	79 or	81	95 or	97	111 or	113	127 or	129
17	33 or	35	50 or	52	67 or	69	84 or	86	101 or	103	118 or	120	135 or	137
18	35 or	37	53 or	55	71 or	73	89 or	91	107 or	109	125 or	127	143 or	145
19	37 or	39	56 or	58	75 or	77	94 or	96	113 or	115	132 or	134	151 or	153
20	39 or	41	59 or	61	79 or	81	99 or	101	119 or	121	139 or	141	159 or	161
21	41 or	43	62 or	64	83 or	85	104 or	106	125 or	127	146 or	148	167 or	169
22	43 or	45	65 or	67	87 or	89	109 or	111	131 or	133	153 or	155	175 or	177
23	45 or	47	68 or	70	91 or	93	114 or	116	137 or	139	160 or	162	183 or	185
24	47 or	49	71 or	73	95 or	97	119 or	121	143 or	145	167 or	169	191 or	193
25	49 or	51	74 or	76	99 or	101	124 or	126	149 or	151	174 or	176	199 or	201
26	51 or	53	77 or	79	103 or	105	129 or	131	155 or	157	181 or	183	207 or	209
27	53 or	55	80 or	82	107 or	109	134 or	136	161 or	163	188 or	190	215 or	217
28	55 or	57	83 or	85	111 or	113	139 or	141	167 or	169	195 or	197	223 or	225
29	57 or	59	86 or	88	115 or	117	144 or	146	173 or	175	202 or	204	231 or	233
30	59 or	61	89 or	91	119 or	121	149 or	151	179 or	181	209 or	211	239 or	241
31	61 or	63	92 or	94	123 or	125	154 or	156	185 or	187	216 or	218	247 or	249
32	63 or	65	95 or	97	127 or	129	159 or	161	191 or	193	223 or	225	255 or	257
33	65 or	67	98 or	100	131 or	133	164 or	166	197 or	199	230 or	232	263 or	265
34	67 or	69	101 or	103	135 or	137	169 or	171	203 or	205	237 or	239	271 or	273
35	69 or	71	104 or	106	139 or	141	174 or	176	209 or	211	244 or	246	279 or	281
36	71 or	73	107 or	109	143 or	145	179 or	181	215 or	217	251 or	253	287 or	289
37	73 or	75	110 or	112	147 or	149	184 or	186	221 or	223	258 or	260	295 or	297
38	75 or	77	113 or	115	151 or	153	189 or	191	227 or	229	265 or	267	303 or	305
39	77 or	79	116 or	118	155 or	157	194 or	196	233 or	235	272 or	274	311 or	313
40	79 or	81	119 or	121	159 or	161	199 or	201	239 or	241	279 or	281	319 or	321
41	81 or	83	122 or	124	163 or	165	204 or	206	245 or	247	286 or	288	327 or	329
42	83 or	85	125 or	127	167 or	169	209 or	211	251 or	253	293 or	295	335 or	337
43	85 or	87	128 or	130	171 or	173	214 or	216	257 or	259	300 or	302	343 or	345
44	87 or	89	131 or	133	175 or	177	219 or	221	263 or	265	307 or	309	351 or	353
45	89 or	91	134 or	136	179 or	181	224 or	226	269 or	271	314 or	316	359 or	361
46	91 or	93	137 or	139	183 or	185	229 or	231	275 or	277	321 or	323	367 or	369
47	93 or	95	140 or	142	187 or	189	234 or	236	281 or	283	328 or	330	375 or	377
48	95 or	97	143 or	145	191 or	193	239 or	241	287 or	289	355 or	337	383 or	385
49	97 or	99	146 or	148	195 or	197	244 or	246	293 or	295	342 or	344	391 or	393
50	99 or	101	149 or	151	199 or	201	249 or	251	299 or	301	349 or	351	399 or	401
51	101 or	103	152 or	154	203 or	205	254 or	256	305 or	307	356 or	358	407 or	409
52	103 or	105	155 or	157	207 or	209	259 or	261	311 or	313	363 or	365	415 or	417
53	105 or	107	158 or	160	211 or	213	264 or	266	317 or	319	370 or	372	423 or	425
54	107 or	109	161 or	163	215 or	217	269 or	271	323 or	325	377 or	379	431 or	433
55	109 or	111	164 or	166	219 or	221	274 or	276	329 or	331	384 or	386	439 or	441
56	111 or	113	167 or	169	223 or	225	279 or	281	335 or	337	391 or	393	447 or	449
57	113 or	115	170 or	172	227 or	229	284 or	286	341 or	343	398 or	400	455 or	457
58	115 or	117	173 or	175	231 or	233	289 or	291	347 or	349	405 or	407	463 or	465
59	117 or	119	176 or	178	235 or	237	294 or	296	353 or	355	412 or	414	471 or	473
60	119 or	121	179 or	181	239 or	241	299 or	301	359 or	361	419 or	421	479 or	481
61	121 or	123	182 or	184	243 or	245	304 or	306	365 or	367	426 or	428	487 or	489
62	123 or	125	185 or	187	247 or	249	309 or	311	371 or	373	433 or	435	495 or	497
63	125 or	127	188 or	190	251 or	253	314 or	316	377 or	379	440 or	442	503 or	505
64	127 or	129	191 or	193	255 or	257	319 or	321	383 or	385	447 or	449	511 or	513
65	129 or	131	194 or	196	259 or	261	324 or	326	389 or	391	454 or	456	519 or	521
66	131 or	133	197 or	199	263 or	265	329 or	331	395 or	397	461 or	463	527 or	529
67	133 or	135	200 or	202	267 or	269	334 or	336	401 or	403	468 or	470	535 or	537
68	135 or	137	203 or	205	271 or	273	339 or	341	407 or	409	475 or	477	543 or	545
69	137 or	139	206 or	208	275 or	277	344 or	346	413 or	415	482 or	484	551 or	553
70	139 or	141	209 or	211	279 or	281	349 or	351	419 or	421	489 or	491	559 or	561
71	141 or	143	212 or	214	283 or	285	354 or	356	425 or	427	496 or	498	567 or	569
72	143 or	145	215 or	217	287 or	289	359 or	361	431 or	433	503 or	505	575 or	577
73	145 or	147	218 or	220	291 or	293	364 or	366	437 or	439	510 or	512	583 or	585
74	147 or	149	221 or	223	295 or	297	369 or	371	443 or	445	517 or	519	591 or	593
75	149 or	151	224 or	226	299 or	301	374 or	376	449 or	451	524 or	526	599 or	601
76	151 or	153	227 or	229	303 or	305	379 or	381	455 or	457	531 or	533	607 or	609
77	153 or	155	230 or	232	307 or	309	384 or	386	461 or	463	538 or	540	615 or	617
78	155 or	157	233 or	235	311 or	313	389 or	391	467 or	469	545 or	547	623 or	625
79	157 or	159	236 or	238	315 or	317	394 or	396	473 or	475	552 or	554	631 or	633

of coils that can be used for the stated numbers of field-magnet poles and armature paths. A six-pole, two-path armature winding, for example, can have either 104 or 106 coils, but not 105; and a six-pole, six-path winding can have 105 or 108 coils but not 103, 104, 106 or 107.

The larger the number of poles, the larger are the gaps between the possible numbers of coils. A 12-pole machine with a 12-path winding, for example, can have only one number of coils in each six existing numbers; if any number between those given should be used, the winding cannot have 12 paths through it. It is largely due to this

TABLE 9. RELATION BETWEEN NUMBER OF COILS AND COMMUTATOR PITCH FOR WAVE WINDINGS WITH A NUMBER OF PATHS EQUAL TO THE NUMBER OF POLES

Commutator Pitch	Number of Armature Coils											
	4 Poles		6 Poles		8 Poles		10 Poles		12 Poles		14 Poles		16 Poles	
5	8 or	12	12 or	18	16 or	24	20 or	30	24 or	36	28 or	42	32 or	48
6	10 or	14	15 or	21	20 or	28	25 or	35	30 or	42	35 or	49	40 or	56
7	12 or	16	18 or	24	24 or	32	30 or	40	36 or	48	42 or	56	48 or	64
8	14 or	18	21 or	27	28 or	36	35 or	45	42 or	54	49 or	63	56 or	72
9	16 or	20	24 or	30	32 or	40	40 or	50	48 or	60	56 or	70	64 or	80
10	18 or	22	27 or	33	36 or	44	45 or	55	54 or	66	63 or	77	72 or	88
11	20 or	24	30 or	36	40 or	48	50 or	60	60 or	72	70 or	84	80 or	96
12	22 or	26	33 or	39	44 or	52	55 or	65	66 or	78	77 or	91	88 or	104
13	24 or	28	36 or	42	48 or	56	60 or	70	72 or	84	84 or	98	96 or	112
14	26 or	30	39 or	45	52 or	60	65 or	75	78 or	90	91 or	105	104 or	120
15	28 or	32	42 or	48	56 or	64	70 or	80	84 or	96	98 or	112	112 or	128
16	30 or	34	45 or	51	60 or	68	75 or	85	90 or	102	105 or	119	120 or	136
17	32 or	36	48 or	54	64 or	72	80 or	90	96 or	108	112 or	126	128 or	144
18	34 or	38	51 or	57	68 or	76	85 or	95	102 or	114	119 or	133	136 or	152
19	36 or	40	54 or	60	72 or	80	90 or	100	108 or	120	126 or	140	144 or	160
20	38 or	42	57 or	63	76 or	84	95 or	105	114 or	126	133 or	147	152 or	168
21	40 or	44	60 or	66	80 or	88	100 or	110	120 or	132	140 or	154	160 or	176
22	42 or	46	63 or	69	84 or	92	105 or	115	126 or	138	147 or	161	168 or	184
23	44 or	48	66 or	72	88 or	96	110 or	120	132 or	144	154 or	168	176 or	192
24	46 or	50	69 or	75	92 or	100	115 or	125	138 or	150	161 or	175	184 or	200
25	48 or	52	72 or	78	96 or	104	120 or	130	144 or	156	168 or	182	192 or	208
26	50 or	54	75 or	81	100 or	108	125 or	135	150 or	162	175 or	189	200 or	216
27	52 or	56	78 or	84	104 or	112	130 or	140	156 or	168	182 or	196	208 or	224
28	54 or	58	81 or	87	108 or	116	135 or	145	162 or	174	189 or	203	216 or	232
29	56 or	60	84 or	90	112 or	120	140 or	150	168 or	180	196 or	210	224 or	240
30	58 or	62	87 or	93	116 or	124	145 or	155	174 or	186	203 or	217	232 or	248
31	60 or	64	90 or	96	120 or	128	150 or	160	180 or	192	210 or	224	240 or	256
32	62 or	66	93 or	99	124 or	132	155 or	165	186 or	198	217 or	231	248 or	264
33	64 or	68	96 or	102	128 or	136	160 rr	170	192 or	204	224 or	238	256 or	272
34	66 or	70	99 or	105	132 rr	140	165 or	175	198 or	210	231 or	245	264 or	280
35	68 or	72	102 or	108	136 or	144	170 or	180	204 or	216	238 or	252	272 or	288
36	70 or	74	105 or	111	140 or	148	175 or	185	210 or	222	245 or	259	280 or	296
37	72 or	76	108 or	114	144 or	152	180 or	190	216 or	228	252 or	266	288 or	304
38	74 or	78	111 or	117	148 or	156	185 or	195	222 or	234	259 or	273	296 or	312
39	76 or	80	114 or	120	152 or	160	190 or	200	228 or	240	266 or	280	304 or	320
40	78 or	82	117 or	123	156 or	164	195 or	205	234 or	246	273 or	287	312 or	328
41	80 or	84	120 or	126	160 or	168	200 or	210	240 or	252	280 or	294	320 or	336
42	82 or	86	123 or	129	164 or	172	205 or	215	246 or	258	287 or	301	328 or	344
43	84 or	88	126 or	132	168 or	176	210 or	220	252 or	264	294 or	308	336 or	352
44	86 or	90	129 or	135	172 or	180	215 or	225	258 or	270	301 or	315	344 or	360
45	88 or	92	132 or	138	176 or	184	220 or	230	264 or	276	308 or	322	352 or	368
46	90 or	94	135 or	141	180 or	188	225 or	235	270 or	282	315 or	329	360 or	376
47	92 or	96	138 or	144	184 or	192	230 or	240	276 or	288	322 or	336	368 or	384
48	94 or	98	141 or	147	188 or	196	235 or	245	282 or	294	329 or	343	376 or	392
49	96 or	100	144 or	150	192 or	200	240 or	250	288 or	300	336 or	350	384 or	400
50	98 or	102	147 or	153	196 or	204	245 or	255	294 or	306	343 or	357	392 or	408
51	100 or	104	150 or	156	200 or	208	250 or	260	300 or	312	350 or	364	400 or	416
52	102 or	106	153 or	159	204 or	212	255 or	265	306 or	318	357 or	371	408 or	424
53	104 or	108	156 or	162	208 or	216	260 or	270	312 or	324	364 or	378	416 or	432
54	106 or	110	159 or	165	212 or	220	265 or	275	318 or	330	371 or	385	424 or	440
55	108 or	112	162 or	168	216 or	224	270 or	280	324 or	336	378 or	392	432 or	448
56	110 or	114	165 or	171	220 or	228	275 or	285	330 or	342	385 or	399	440 or	456
57	112 or	116	168 or	174	224 or	232	280 or	290	336 or	348	392 or	406	448 or	464
58	114 or	118	171 or	177	228 or	236	285 or	295	342 or	354	399 or	413	456 or	472
59	116 or	120	174 or	180	232 or	240	290 or	300	348 or	360	406 or	420	464 or	480
60	118 or	122	177 or	183	236 or	244	295 or	305	354 or	366	413 or	427	472 or	488
61	120 or	124	180 or	186	240 or	248	300 or	310	360 or	372	420 or	434	480 or	496
62	122 or	126	183 or	189	244 or	252	305 or	315	366 or	378	427 or	441	488 or	504
63	124 or	128	186 or	192	248 or	256	310 or	320	372 or	384	434 or	448	496 or	512
64	126 or	130	189 or	195	252 or	260	315 or	325	378 or	390	441 or	455	504 or	520
65	128 or	132	192 or	198	256 or	264	320 or	330	384 or	396	448 or	462	512 or	528
66	130 or	134	195 or	201	260 or	268	325 or	335	390 or	402	455 or	469	520 or	536
67	132 or	136	198 or	204	264 or	272	330 or	340	396 or	408	462 or	476	528 or	544
68	134 or	138	201 or	207	268 or	276	335 or	345	402 or	414	469 or	483	536 or	552
69	136 or	140	204 or	210	272 or	280	340 or	350	408 or	420	476 or	490	544 or	560
70	138 or	142	207 or	213	276 or	284	345 or	355	414 or	426	483 or	497	552 or	568
71	140 or	144	210 or	216	280 or	288	350 or	360	420 or	432	490 or	504	560 or	576
72	142 or	146	213 or	219	284 or	292	355 or	365	426 or	438	497 or	511	568 or	584
73	144 or	148	216 or	222	288 or	296	360 or	370	432 or	444	504 or	518	576 or	592
74	146 or	150	219 or	225	292 or	300	365 or	375	438 or	450	511 or	525	584 or	600
75	148 or	152	222 or	228	296 or	304	370 or	380	444 or	456	518 or	532	592 or	608
76	150 or	154	225 or	231	300 or	308	375 or	385	450 or	462	525 or	539	600 or	616
77	152 or	156	228 or	234	304 or	312	380 or	390	456 or	468	532 or	546	608 or	632
78	154 or	158	231 or	237	308 or	316	385 or	395	462 or	474	539 or	553	616 or	632
79	156 or	160	234 or	240	312 or	320	390 or	400	468 or	480	546 or	560	624 or	640

restriction that lap-connected windings are used instead of wave-connected multipath windings in machines having large numbers of field-magnet poles. The wave-connected winding has the very great advantage that every path through it is subjected to exactly the same magnetic effect, regardless of differences between the strengths of different field-magnet poles, but the gaps between the available numbers of armature coils are equal to one-half the number of field-magnet poles. The multipath wave-connected winding is also subject to some disadvantages as to commutation, which will be discussed later.

GAS POWER DEPARTMENT

New Heavy-Oil Engine

By A. E. Ballin

The Diesel or high-compression-type oil engine is unique in that it was designed to fit a theory. Previous prime movers had first been built and run by practical men, and the theoretical considerations governing their operation were later formulated to account for observed results. The descriptive matter in Doctor Diesel's original patent shows that he was in error in several particulars. For instance, it was claimed that the engine would not require any artificial cooling as the expansion of the products of combustion would reduce the temperature to such a degree that the mean temperature of the parts would be low enough so as not to interfere with proper lubrication. It was even claimed that by cooling the air during the first part of the compression, the exhaust gases would be cooled even below the temperature of the surrounding atmosphere, and might be used for refrigerating purposes. The fundamental theory, however, was sound, and these early misconceptions probably had no other effect than to delay the attainment of a successful design.

The high-compression-type oil engine has been built in the United States for about a decade, but it has never made the progress here that it has in Europe. This has been due largely to economic reasons. With the expiration of Diesel's fundamental patent in July, 1912, however, an impetus was given to the development in this country.

California and Mexican Oils

There is produced in California and in Mexico an abundance of crude oil containing high percentages of asphalt and sulphur, but relatively small amounts of gasoline and the lighter distillates. Hence, these oils have found their principal market as fuel for the generation of steam.

In California alone, a monthly production in excess of 700,000 barrels, was recently made practically useless by the decision of the Standard Oil Co. to purchase no more crude oil below 18 deg. gravity Baumé. This rate of production would supply 650,000 hp. of oil-engine capacity with fuel running at full load 24 hr. per day continuously. To what extent the economies of water transportation may effect the market for low-grade oil after the Panama Canal is opened is not now apparent, but that the field will be broadened, there can be no question.

The problem to be solved if the oil engine is to become a competitor of other forms of prime movers, except in special cases, is, therefore:

> To produce an engine which can utilize the low-grade asphalt-base crude oils of the Pacific coast and Mexico, with their high percentage of asphalt and sulphur, or other low-grade oils, and to so design the engine that the ordinary engineer need have no difficulty in maintaining it in satisfactory operation, without requiring frequent or costly repairs.

These considerations led the Snow Steam Pump Works to take up this new line of prime movers. As a preliminary, an investigation was conducted through its agents in Europe as to types, sizes, magnitude of the business, etc., of European builders. Later, representatives went abroad to get a first-hand knowledge as to conditions under which engines were operating, the troubles that were being experienced, etc.

High Compression vs. Medium Compression

The first question to be settled was whether the engine should operate on the high-compression principle, or whether some modification should be made in it; that is, whether a medium-compression type of engine should be built. In all of these, some form of auxiliary-ignition apparatus is used. The claims made for such engines are:

> That they can be made lighter for the same horsepower on account of the lower compression and are consequently cheaper.
>
> That they can be run with a mechanical oil-spraying device, thereby avoiding the necessity of supplying compressed air for spraying the fuel, which still further reduces the first cost of an installation.

Many engines of this type that were seen running showed a smoky exhaust. It is obvious that if the lighter oils will not burn clean, the heavy asphalt base oils, will soon clog the internal parts of the engine.

A modification of the medium-compression type by the addition of an air-spraying valve to inject the fuel, improves the combustion and economy, but nullifies certain arguments in favor of this type. Even with the lower compression, the injection of fuel into a hot vaporizing chamber causes an explosive rise in pressure to a point quite as high as is essential in a high-compression engine. This means that the engine must be as strong and as well constructed as the high-compression engine and must have all of the essential mechanism, in addition to the vaporizing chamber.

There are several disadvantages of a vaporizing chamber. It must be heated with a blow torch to a dull red before starting in order to ignite the fuel and in this the engineer must exercise his judgment as to when it is hot enough. Of more importance is its influence on the design of the cylinder head. The vaporizing chamber must be so placed in relation to the fuel-injection nozzle that the oil is injected into the center of the chamber. The spray valve cannot then be placed in the center of the cylinder head on the longitudinal axis of the cylinder, which is its natural location. The large opening in the cylinder head for the vaporizing chamber in addition to openings for inlet and exhaust valves, air-starting valve and spray nozzle, together with the resulting lack of symmetry, results in a cylinder-head design not well adapted to resist combined stresses due to high temperatures and pressures within the cylinder.

The high-compression engine, on the other hand, can be started cold and brought up to speed in a minute or less. The compression increases gradually until the maximum is reached. This maximum compression pressure

ttained need not be exceeded when the fuel is injected, he effect of the resulting combustion being to maintain he pressure constant at the highest point of the com-ression for a certain time, depending on the load, after hich expansion takes place with a gradual fall in pres-

ber of months, using the various grades of oil available in different parts of the country, demonstrated that the asphalt-base oils could be completely consumed within the cylinder. The exhaust from the engines is invisible, and practically odorless, except when oils containing sulphur

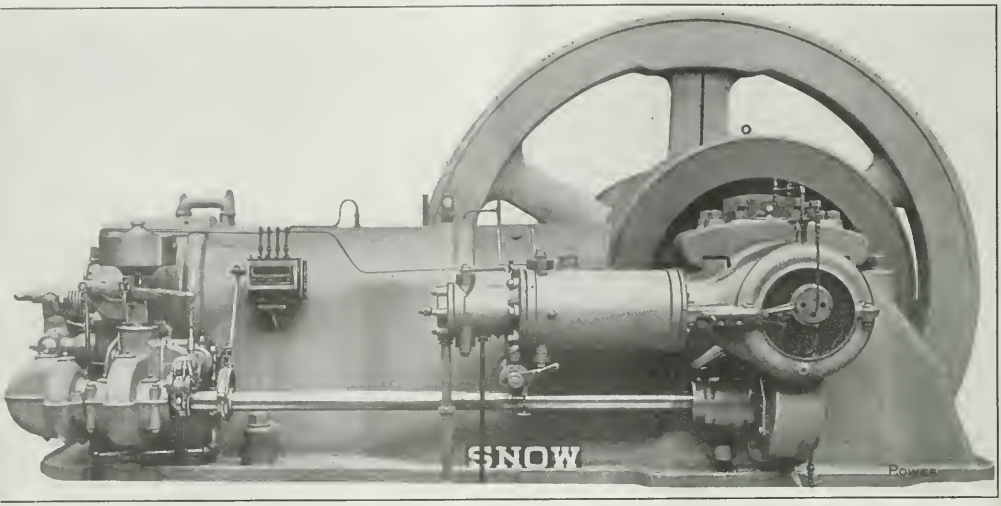


Fig. 1. Snow Horizontal Oil Engine

ure until the exhaust valve opens. The result is that he engines run quietly and without shock on all loads nd it is almost impossible to tell whether an engine is unning light or loaded when standing beside it, pro-ided the sound of the exhaust cannot be heard.

The decision arrived at after giving due consideration

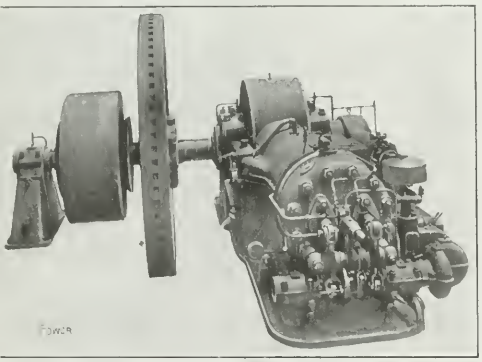


Fig. 2. Head End of Engine

o all of these factors was that the high-compression hori-ontal type was preferable.

The Snow Engine

The first engine built was a single-cylinder, single-act-ng, four-stroke-cycle type rated at 110 b.hp. and run-ing at 180 r.p.m. Experiments extending over a num-

are being used, in which case the characteristic odor of sulphur dioxide is noticeable.

Fig. 3 shows the fuel-consumption curve when using California crude oil of 15.5 deg. Baumé. This shows the curve to be very flat between loads of 80 to 115 b.hp. Fig. 1 is a side view of the engine and Fig. 2 shows the head end.

These engines are suitable for any application to which stationary engines are adaptable, including driving di-

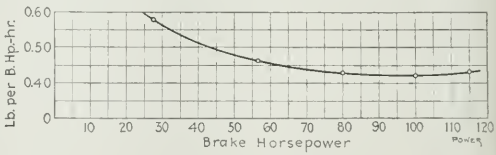


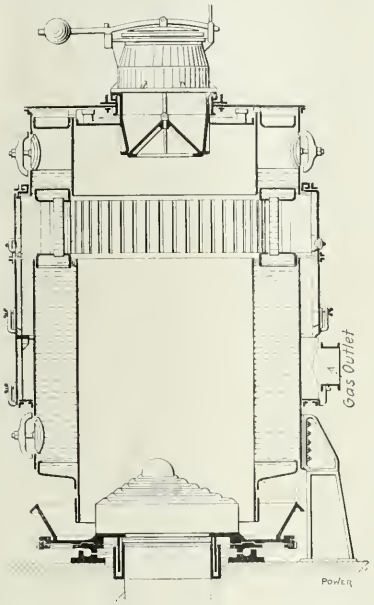
Fig. 3. Load Curve

rect-connected, 60-cycle, alternating-current generators in parallel. For this latter service engines of 175 to 750 b.hp. can be furnished. For less exacting requirements, as, for instance, general power purposes, or for driving direct-current generators, engines as low as 30 b.hp. are being built.

One quart of cylinder-lubricating oil for ten hours' run has been found to be sufficient to keep the cylinder, the inlet-valve stem and the exhaust-valve stem of the 110-hp. engine properly lubricated. The shaft bearings and cranks are supplied with oil from a gravity system. After passing through a settling tank and filter the oil is returned to the overhead tank to be used again. The cam and lay shafts are lubricated with ring oilers and the gears all run in oil.

Combined Producer and Boiler

In its foreign review, the *Journal* of the American Society of Mechanical Engineers, for July, contains a brief description of a combined gas producer and boiler, designed by Chief Engineer Marischka, of the Vienna Municipal Gas Works. As shown in the illustration, the producer has a revolving grate and the cylinder or shell for its full length is made into a steam boiler, divided into two sections with water tubes between. In addition,



SECTION THROUGH PRODUCER

a jacket is provided, which forces the gases to flow along the surface of the boiler for a considerable distance.

This arrangement has made it possible to reduce the temperature of the gases leaving the producer to about 425 deg. F., while steam is generated at 85 lb. gage. Only part of the steam is required for the producer itself and the rest is available for other purposes.

The chief value of this producer lies in the fact that it takes care of cooling the gases down to near the temperature at which they can be conveniently handled in the gas engine, and at the same time utilizes their excess of heat. This is not the first attempt to combine a gas producer with a boiler, but it is only the revolving grate that has made such a construction commercially practicable, owing to the large amount of fuel handled, and the large amount of heat developed per unit of producer cross-section.

Gas-Engine Explosion

BY J. W. LEHMAN

A most unusual explosion of a gas engine took place at the plant of the Hardin-Wyandotte Lighting Co., of Kenton, Ohio, on July 18, which resulted in injury to two men, neither fatally however. Usher Wetherill, the day engineer, sustained a broken leg while William Wilson, the night engineer was badly bruised. Both men were standing on the platform at the time and Wetherill was explaining some details to Wilson when he accidently touched the governor. This immediately opened the throttle and such a large quantity of gas was sucked in as to find its way into the crank case. The heated condition of this chamber caused an explosion which blew out the side of the crank case. The men were standing against the crank case at the time, which fact accounts for their comparatively slight injuries, as they were pushed rather than thrown off the platform. The side of the crank case was thrown a distance of 20 ft.

The engine is rated at 150 hp., runs on natural gas and has been in operation for more than a year.

Another unit, which was in reserve, was immediately started; hence the accident did not cripple the service to any great extent. Repairs were made within a few days and the new crank case is fitted with safety devices consisting of thin layers of metal placed opposite each cylinder; these will blow out and relieve the pressure before the walls of the crank case will give way.

Some Observations on Marine Diesel Engines

BY DR. L. K. HIRSHBERG

Advocates of the application of the Diesel engine to large vessels are endeavoring to curb to a degree the overenthusiasm of its radical supporters who are prone to claim too much for this type of engine on account of the success of such vessels as the "Selandia" and the more recently built "Eavestone."

At a discussion last summer in regard to cargo vessels generally a lower price for oil than $2.50 per barrel seemed to be needed to enable it to compete as fuel in internal-combustion engines, with coal-fired boilers and steam engines or turbines. There are, however, exceptional cases of vessels that have to perform very long voyages, carrying their own fuel where the advantages of a minimum consumption are paramount. On the other hand, there are cases which are much less favorable to oil. The short experience so far obtained with large oil engines on board ship (while eminently satisfactory and encouraging to builders and owners) makes speculation difficult as yet, and it remains for further practical experience over a term of years before definite and accurate figures will be available as to reliability and upkeep.

The East Asiatic Co. already has six passenger and freight vessels, equipped with Diesel engines, in commission to send through the Panama Canal when it opens, and six more vessels of like design are under construction and will be ready to join the fleet in handling traffic from Europe via the canal. After careful experiments, this company reports the net earnings of their steam vessels at 8 per cent. per annum, and those having Diesel motors at 20 per cent. on the capital invested.

The "Fionia," one of the company's finest vessels and now on the stocks at Copenhagen, has been selected as the first vessel of the fleet to make the trip.

About 400 vessels using Diesel engines are now in service and 60 are being built. Freight vessels of from 6000 to 10,000 tons are being equipped with these engines, but as yet they have not proved available for fast boats, as the speed has never developed much over 12 knots an hour.

HEATING AND VENTILATION

Physical Action of Steam and Forced Hot-Water Heating Systems

By Ira N. Evans

The following question was recently asked in connection with the comparisons of methods of heating by steam and water by forced circulation: Does the hot-water system require a longer time to heat up a building than a steam system? At first thought one would conclude that the water system required the longer period and in this respect is at a disadvantage. There are several elements that should be taken into consideration in answering this question by a simple affirmative or negative.

In the first place, the point involved assumes importance only where intermittent operation is contemplated. From actual tests continuous operation has proved more economical for large heating plants. If a plant required 100 boiler hp. to maintain the rooms at a constant temperature and was shut down for 10 hr., then 1000 hp.-hr., or 500 boiler hp. would be required to replace in two hours the heat radiated during the 10-hr. period and raise the temperature of the rooms to the same degree as before the plant was shut down. The actual power used is nearly the same, but the intermittent operation of the greater boiler capacity for short periods is exceedingly wasteful and expensive to say nothing of the investment in extra boilers.

Under these conditions the greater density of the water would seem a disadvantage, due to the greater quantity of heat stored. There is actually nothing lost as this heat would be given off during the period of non-operation, preventing the building temperature from dropping as low as with the steam medium. It will be seen later that the heat absorbed by the cubic contents of the system is not a large proportion of the total heat requirements to maintain the room contents, walls and floors at the required temperature. All sprinkler and water pipes, furniture, machinery and masonry store the heat and have to be raised to the proper temperature before the building is actually warm.

This heat is given out when the apparatus is inoperative and all has to be replaced. The above statements apply to any heating system, whether water or steam, and the larger the plant and building the more heat has to be provided when intermittent operation is contemplated.

A heating apparatus is a device for conveying and distributing heat, and the best system will be the one capable of delivering the greatest quantity in the shortest space of time. It makes little difference how much heat the system itself absorbs, it is the rapidity and efficiency with which the heat can be transferred from the source to the building. However great the capacity of the heating system for conveying and distributing the heat, ample boiler power must be provided to meet the demand, and as the boiler power is decreased the period required to raise the temperature of the building will increase independent of the type of system. Most well designed heating systems will have conveying capacity far in excess of the boiler power provided, and it will be found that the latter item will generally be the limiting factor.

When steam at constant pressure and temperature is used as a heating medium, the only mehod of varying the steam requirements of the system for outside weather changes is by automatic heat control locally applied whereby overheating is prevented by shortening the period of operation and turning the radiators on and off. Where automatic heat control is not applied the overheating of the steam system is partially overcome by intermittent operation. This gives a variable temperature in the rooms. It is cold in the morning and hot at night.

With water circulation the entire medium may be changed in temperature through a considerable range to accomplish the same object. A constant temperature may easily be maintained in the building with a steam consumption in proportion to the outside weather requirements with all radiators in operation. This method, for best and most economical results, requires continuous operation. The average change or variation from day to day in the outside temperature is seldom more than 15 deg. and the hourly change is much less.

A few figures will give a better idea of the actual relation and importance of the quantities involved. A heating system aggregating 30,000 sq.ft. of radiation will be assumed, operating at the same average maximum temperature of 210 deg. for both the steam and water. The surface of the steam system may be slightly higher in temperature at times than that of the water system, but the advantage in density and velocity of the water over the heating surface will more than offset any possible difference in temperature.

The same initial steam temperature of 225 deg. will be assumed for both systems. The water system will have an outboard temperature of 220 deg. and return of 200 deg. or an average of 210 deg., while the steam system will have the same average temperature in the radiators, allowing for drop on the mains, or 10 to 5 deg. less than the initial steam temperature.

It is a fair assumption that the radiation on both systems will do the same work in zero weather and radiate the same amount of heat. Steam at atmospheric pressure has a volume of nearly 27 cu.ft. to the pound. The water at the temperatures used for heating has an average density of about 61 lb. per cu.ft. The latent heat of the medium on the steam system will be taken at 970 B.t.u. Both heating systems will be assumed to have a cubic content of about 30 cu.in. to the square foot of heating surface, or 35 cu.in., including mains. Then

$$\frac{30{,}000 \times 35}{1728} = 608 \ cu.ft.$$

The amount of heat transferred by the radiation in zero weather by either system will be the same per hour

$$30{,}000\ sq.ft. \times 1.8\ B.t.u. \times (210\ deg. - 70\ deg.) = 7{,}560{,}000\ B.t.u.$$

This will be assumed to exactly balance the heat losses of the building and maintain 70 deg. in the rooms. The probable average temperature of the water 75 per cent. of the time will be 160 deg. and the heat necessary will be

$$30{,}000 \times 1.7 \times (160 - 70) = 4{,}590{,}000\ B.t.u.$$

The probable minimum temperature of the water system will be 120 deg., or

$$30{,}000 \times 1.6 \times (120 - 70) = 2{,}400{,}000\ B.t.u.\ per\ hr.$$

If automatic heat control is provided the steam system may utilize the same total heat units as the hot-water system, but it is accomplished by shutting off the individual radiators entirely for longer and longer periods as the outside weather becomes warmer. The temperature of the radiator remains at 210 deg. and sometimes is a little higher in moderate weather. If there is no automatic control, and occupants open the windows, due to overheating, leaving the radiator turned on, the steam consumption for the heating system will be about the same one day as another. Many people think that exhaust steam costs nothing and neglect to take advantage of the periods of light load, when with automatic control there would be no occasion to supply live steam to make up a shortage in the supply of exhaust steam.

A vacuum steam system with automatic heat control will cost more to install than a hot-water system, and is simply a case of intermittent heating on a large scale with individual radiators.

For all heating systems the piping is figured for the maximum capacity in zero weather. Sometimes allowance is made for intermittent heating by increasing the radiation, but as a rule the lower temperature of the rooms when heating up will increase the transmission of the radiators sufficiently. With a 2-lb. drop between the engine and the radiation the main for this job would be approximately 12 in. in diameter with a velocity in the main of 86 ft. per sec.

The hot-water main for a maximum drop of 20 deg. in zero weather for the same capacity and 1000 ft. of mains when pumping against 50 to 75 ft. head would be 6 in. in diameter. The quantity of water in pounds pumped per minute would be

$$\frac{7{,}560{,}000}{20\ deg. \times 60\ min.} = 6300$$

The difference in size of main is due directly to the relative densities and velocities of the two mediums. The water will have the same size supply and return, while the steam will have a much smaller return pipe.

The maximum capacity of the steam mains will be about 0.3 lb. per sq.ft. of radiation per hour, or in this case

$$30{,}000\ sq.ft. \times 0.3\ lb. = 9000\ lb.\ steam\ per\ hr.$$

This capacity may be considerably increased by raising the steam pressure and increasing the density of the steam. At 15-lb. gage pressure there would be about 14 cu.ft. to the pound instead of 27 cu.ft. at atmospheric pressure, and the temperature of the radiators would be about 240 deg. instead of 210. The capacity of the mains would be doubled at the same velocity, but this would mean back pressure when operating on exhaust steam.

In the medium the heat above 32 deg. at any instant when operating at 210-deg. temperature will be for the steam system, 1150 B.t.u. per lb., and for the water 178 B.t.u. per lb. The total heat in the steam system at 210 deg. when shut down would then be

$$\frac{1150 \times 608}{27} = 25{,}896\ B.t.u.$$

Under the same conditions the total heat in the water system would be

$$608 \times 61 \times 178 = 6{,}601{,}664\ B.t.u.$$

These figures indicate the available heat in either system to prevent freezing after shutting down.

To this in both cases must be added the heat stored in the metal of either system from 32 to 210 deg. There are 7 lb. of metal per square foot of surface if cast-iron radiators are used on either system, and the specific heat is 0.13. Then

$$30{,}000 \times 7 \times 178 \times 0.13 = 4{,}859{,}400\ B.t.u.$$

$$25{,}896 + 4{,}859{,}400 = 4{,}885{,}296\ B.t.u.$$

This would be

$$\frac{4{,}885{,}296}{7{,}560{,}000} = 0.646$$

or practically 65 per cent. of one hour's requirements under maximum conditions for the steam system. The water system would have

$$6{,}601{,}664 + 4{,}859{,}400 = 11{,}461{,}064\ B.t.u.$$

$$\frac{11{,}461{,}064}{7{,}560{,}000} = 1.516$$

or nearly 152 per cent. of one hour's maximum demand. On shutting down, the water system has 324 per cent. as much residual heat as the steam. The heat in either system available for heating after shutting down before the room cools below 70 deg. will be as follows:

In the steam system only the latent heat of the steam is available for this purpose, or 970 B.t.u. per lb.

$$\frac{970 \times 608}{27} = 21{,}843\ B.t.u.$$

The iron will contain in both systems

$$210{,}000\ lb. \times 0.13 \times 140\ deg. = 3{,}822{,}000\ B.t.u.$$

The total for the steam system will then be

$$21{,}843 + 3{,}822{,}000 = 3{,}843{,}843\ B.t.u.$$

The water after shutting down at a temperature of 210 deg. will contain above 70 deg.

$$608 \times 61 \times 140 = 5{,}192{,}320\ B.t.u.$$

Adding the heat in the iron gives

$$3{,}822{,}000 + 5{,}192{,}320 = 9{,}014{,}320\ B.t.u.$$

This will permit of

$$\frac{9{,}014{,}320}{7{,}560{,}000} = 1.19\ hr.$$

operation at the maximum rate for the water system and

$$\frac{3{,}843{,}843}{7{,}560{,}000} = 0.508$$

or 51 per cent. of one hour's operation for the steam system. The water system has $2\frac{1}{3}$ times as much heat as the steam system, so if the period of shutdown is not too long, the hot-water system will have less work to do when the system is started again. The steam system has practically no storage outside of what remains in the cast-iron radiation. This accounts for the suddenness with which steam-heated rooms cool off when the radiators are turned off. In sheet-metal radiators which weigh something like $1\frac{1}{4}$ lb. per sq.ft. instead of 7 lb. for cast iron, the heat storage would be less than for cast iron

and the time of heating up would be considerably reduced.

On the water system the pumpage has been determined for a 20-deg. drop as 6300 lb. per min. The system contains 608 cu.ft. of water at 61 lb., so

$$\frac{608 \times 61}{6300} = 5.89 \ min.$$

The water would be completely displaced every 6 min. The steam system would be displaced

$$\frac{7{,}560{,}000 \times 27}{970 \times 608} = 346.1$$

times per hour or 5.77 times per min. This would be 31.6 times as often as the water system. The available heat units each time the system is filled with steam will be, as previously determined, 21,843 B.t.u. The water system has a variable capacity of heat transmission depending on its temperature. This depends on the drop which increases in the heaters and decreases on the radiation as the temperature is lowered with the same circulation. There will be given up to the building in cooling the entire contents of the water system or will be introduced each time the entire radiation is raised one degree in temperature.

$$608 \times 61 = 37{,}088 \ B.t.u.$$

For the iron there will be

$$30{,}000 \times 7 \times 0.13 = 27{,}300 \ B.t.u.$$

This will mean

$$\frac{64{,}388}{970 \times 34.5} = 1.92 \ hp. \ per \ deg. \ change$$

The water system is only changed a few degrees in temperature while the steam radiators are cooled down entirely to the temperature of the room, 70 deg., and heated to the full temperature of 210 deg. each time they are turned on. This would mean in heat if each radiator were shut off once per day.

$$21{,}843 + 27{,}300 \ (210 - 70) = 3{,}843{,}843 \ B.t.u.$$

$$\frac{3{,}843{,}843}{970 \times 34.5} = 114.9 \ hp.$$

If the water were changed 30 deg. in temperature in one day it would mean only

$$1.92 \times 30 = 57.6 \ hp.$$

or less than half. In moderate weather the change on the water system would be very much less, while radiators on the steam system would be turned on and off more frequently, with longer intervals between. The above applies to continuous operation, which is the method adopted for plants of this size. There is nothing lost in either case as the residual heat is given off and maintains the room for a longer period before the heat is turned on again.

Under the maximum conditions the water system will transfer, each time it is filled and emptied,

$$37{,}088 \ lb \times 20 \ deg. = 741{,}760 \ B.t.u.$$

as against 21,843 B.t.u. for the steam system. The action of the two systems in heating up is somewhat different. The water system is at nearly the same temperature throughout and when heating rooms the radiators are heated gradually all at the same time. In the steam system all radiators are heated from minimum to maximum one at a time. The water job may take 2 hr. to heat up, but all rooms will receive a portion of the heat at the same time, while it will be nearly the full interval of time before the last radiator on the steam job receives any heat at all.

The time necessary to raise the building from 10 deg. outside and in to 70 deg. in the rooms with a temperature on either system not exceeding 210 deg. at any time will be determined. A temperature of 10 deg. was assumed because if the building was at a lower temperature with a lower outside temperature either system would be incapable of raising the rooms to 70 deg. until the weather became warmer or the pressure and temperature and boiler power were increased for the time being. It has been determined that 7,560,000 B.t.u. is required to replace the heat loss of the building at 70 deg. inside and zero outside. This capacity per hour cannot be increased on the steam system without changing the pressure and temperature. The rate per degree per minute would be

$$\frac{7{,}560{,}000}{60 \times 70} = 1800 \ B.t.u.$$

If the heat loss from the building is being replaced at the same time the temperature of the rooms is being raised it will take 3600 B.t.u. per deg. raise per min. The capacity of the steam mains at the temperature named will be 9000 lb. per hr., which will supply 8,730,000 B.t.u. per hr., or 145,500 B.t.u. per min. The iron in the job will require

$$30{,}000 \times 7 \times 0.13 \ (210 - 40) = 4{,}641{,}000 \ B.t.u.$$

To find the total heat required to raise the steam system from 40 to 210 deg. with a steam temperature of 210 deg. at a rate of 145,500 B.t.u. per min., divide the series of radiators and the heat required for the cast iron into three parts.

$$\frac{4{,}641{,}000}{3} = 1{,}547{,}000 \ B.t.u.$$

The first section of 10,000 sq.ft. will radiate heat at an average of say 50 deg. and will take

$$10{,}000 \times 1.8 \ (210 - 50) = 2{,}880{,}000 \ B.t.u. \ per \ hr.$$

$$\frac{2{,}880{,}000}{60} = 48{,}000 \ B.t.u. \ per \ min$$

The iron in the first section will heat up in

$$\frac{1{,}547{,}000}{145{,}500 - 48{,}000} = 15.9 \ min.$$

When the second section is heating up it will be necessary to supply the radiation in the first and second sections and the iron in the second section. The radiation of the second section at 60 deg. will require

$$10{,}000 \times 1.8 \ (210 - 60) = 2{,}700{,}000 \ B.t.u. \ per \ hr.$$

$$\frac{2{,}700{,}000}{60} = 45{,}000 \ B.t.u. \ per \ min.$$

then

$$\frac{1{,}547{,}000}{145{,}500 - (48{,}000 + 45{,}000)} = 29.5 \ min.$$

When the third section is heating up, the radiation at 70 deg. will require

$$10{,}000 \times 1.8 \ (210 - 70) = 2{,}520{,}000 \ B.t.u. \ per \ hr.$$

$$\frac{2{,}520{,}000}{60} = 42{,}000 \ B.t.u. \ per \ min.$$

$$\frac{1{,}547{,}000}{145{,}500 - (48{,}000 + 45{,}000 + 42{,}000)} = 147.4 \ min.$$

The total time will then be

$$15.9 + 29.5 + 147.3 = 192.8 \ min. = 3.21 \ hr.$$

TABLE I

Aver. Temp. Water Deg. F.	Dif. Water and Steam Temp. in Heater 325°	Ratio Showing Decrease in Heater Cap.	Heater Cap. in Per Cent.	Cap. of Heater B.t.u. per Hour	Cap. of Heater B.t.u. per Min.	Rise Water Temp. Deg. F.	Cap. Heater in Boiler Hp.	Rise in Temp. Iron and Water from 40°	Final Temp. Deg. F.	B.t.u. Required by Iron (210,000×0.13 per deg.)	B.t.u. Required by Water (37,088 Lb.)	Total B.t.u. Required by Iron and Water	B.t.u. per Hr. Transmitted to Bldg.	B.t.u. per Hour Delivered to Bldg.	B.t.u. per Min. Delivered to Bldg.	Min. for each Period Col. XII ÷ Col XV	Total Time	Total Rise Temp. Each Period	Heat Applied to Raise Temp. Bldg. from 40 Deg. Outside	TotalB.t.u. Applied From 40 Deg. to End Each Period	Trans. each Period × Col. XVII
I	II	III	IV	V	VI	VII	VIII	IXa	IXb	X	XI	XII	XIII	XIV	XV	XVI	XVII	XVIII	XIX	XX	XXI
75	250	$\frac{250}{115}$	217	19,530,000	325,500	51 7	567	70	110	1,911,000	2,596,160	4,507,160	30,000×1 6x (75—40)	5,580,000	28,000	15 15	15 15	7 8	424,200	424,200	54,540
123	202	$\frac{202}{115}$	176	15,840,000	264,000	42	459	95	135	682,500	927,200	1,609,700	30,000×1 6x(123—48)	3,600,000	60,000	7 80	23 04	10 82	473,400	897,600	82,944
148	177	$\frac{177}{115}$	154	13,860,000	231,000	37	402	120	160	682,500	927,200	1,609,700	30,000×1 6x(148—51)	4,656,000	77,600	10 5	33 54	14 18	814,800	1,712,400	120,744
172	153	$\frac{153}{115}$	133	11,970,000	199,500	32	347	145	185	682,500	927,200	1,609,700	30,000×1 7x(172—54)	6,018,000	100,300	16 22	49 76	18 63	1,626,866	3,339,266	179,136
193	132	$\frac{132}{115}$	115	10,350,000	172,500	27 4	300	160	200	409,500	556,320	965,820	30,000×1 7x(193—56)	6,834,000	113,900	16 48	66 24	21 87	1,877,072	5,216,338	238,464
210	115	$\frac{115}{115}$	100	9,000,000	150,000	24	261	170	210	273,000	370,880	643,880	30,000×1 8x(210—63) 30,000×1 8x(210—67)	7,938,000 7,722,000	132,300 128,700	36 37 30	102 61 152 61	27 15 29 964	4,811,751 6,435,000	10,028,089 10,463,088	399,369 549,396
													Total.....								

The heat delivered to the room will be approximately

		B.t.u.
15.9 ×	48,000 =	763,200
29.5 ×	93,000 =	2,743,500
147.4 ×	135,000 =	19,899,000
		23,405,700

At a rate of 3600 B.t.u. per min., the radiating surface will give off

$$192.8 \times 3600 = 694{,}080 \textit{ B.t.u. per deg. rise}$$

so that the rise in the temperature will be

$$\frac{23{,}405{,}700}{694{,}080} = 34 \textit{ deg.}$$

and the rooms will be at a temperature of 40 + 34 = 74 deg. This, of course, contemplates no increase in pressure or temperature of the steam.

The time of heating up in both systems should be calculated by calculus, using infinitesimal increments of radiation for the steam and temperatures for the water, as the smaller these increments are the nearer accurate the summation of the series. The method followed is more simple, however, and near enough for purposes of comparison.

The table gives the time of heating up with a hot-water system worked out along the same lines. As the water starts off at 40 deg., the heater capacity is enormously increased as shown in cols. IV, V and VI. The boiler horsepower is given in col. VIII. Any reduction in this will increase the length of time required. Average and final temperatures of water are given in col. IX. The B.t.u. required for the iron and water are given in cols. X, XI and XII. The rate of transmission of heat is given in cols. XIII, XIV and XV and the time for each period in minutes in col. XVI. The total time required is 152 min. The total rise in temperature of the room is given in col. XVIII as 29.964 deg. The last quantity in col. XVI, 50 min., was assumed as the time to actually raise the room to 70 deg., would be indefinite if considered theoretically.

The action of the two systems is as follows: The steam has the maximum transmission of heat from the radiators at the beginning, while the water is maximum at the final period. The steam system will have required 23,392,200 B.t.u. in 192.7 min. and the water 25,911,274 B.t.u. in 152.6 min.

Primarily both systems depend on the available boiler power in the building. The high horsepower for the water system, 567, is only required for 15 min. It would be impossible on the steam system to introduce the heat more rapidly without a change in pressure and temperature. As a matter of practical operation the water system when starting off at the beginning of the heating season would require for the water the minimum temperature of 120 deg. This would require a transmission to the building of 2,400,000 B.t.u. To raise the iron to 120 deg. from, say, 70 deg., would take

$$30{,}000 \times 50 \times 0.13 \times 7 = 1{,}365{,}000$$

The water would require

$$608 \times 50 \times 61 = 1{,}854{,}400$$

making a total of 3,219,400 B.t.u. The rate of transmission per minute is $\frac{2{,}400{,}000}{60} = 40{,}000$ B.t.u. The time of heating up the iron at a rate in the heater of 264,000 B.t.u. per min. will be

$$\frac{3,219,400}{264,000 - 40,000} = 14.4 \text{ min.}$$

For the steam system it will require 3.21 hr. before the iron in all the radiators is up to 210 deg., the temperature of the medium.

In actual practice the steam consumption of the steam system with automatic control and the hot-water system system would be practically the same under continuous operation, but the advantage would lay with the water system in moderate weather (75 per cent. of the time) in its ability to utilize exhaust steam under temperatures corresponding to fair vacuums. The temperature at which the steam is utilized in the vacuum system would be constant and near 215 deg. regardless of the requirements.

The discussion shows that the water system will resist freezing longer, maintain the temperature of the rooms longer after a shutdown, and can be heated up quicker than a vacuum steam system unless the pressure and temperature of the steam are increased.

Flow of Water in Shunted Radiators

Some time ago Mr. Durand, in his criticism of Mr. Brewster's article on the flow of water through radiators connected in shunt with the supply main of a forced hot-water system, presented a view of the subject quite as incorrect as that in the article criticized. Both theories are wrong because each disregards the basis of the other.

Mr. Brewster's idea, that the flow in the shunt is produced solely by the difference in the weights of the ascending and descending columns of water *A-B* and *C-D*, Fig. 1, is incomplete in that it does not take into account the differential pressure produced by the friction of the shunted portion of the main *E-F*, and would in most cases lead to the use of excessively large radiator branches. However, a system designed on this basis would operate satisfactorily but with a temperature drop in the shunt circuit much smaller than that expected by the designer.

Mr. Durand's contention that there would be no circulation if a tank were substituted for the supply main and the radiator branches were left uncovered, is disproved by the many gravity hot-water systems now in operation in which none of the piping is covered. To demonstrate more positively that there will be a flow under these conditions, it would be well for those still in doubt to try the following simple experiment which will show the action very clearly:

In Fig. 2, *C* is a receptacle filled with warm water, colored by adding a few drops of ink, and *A-B* is a siphon formed of $\frac{1}{4}$-in. glass tubing. *A-B* is filled with clear, cold water, care being taken to drive out all air bubbles, then inverted and held so that both ends come below the surface of the colored warm water. Upon removing the fingers from the ends of the tube it will be found that the colored water will rise in one of the vertical sections and in a few seconds fill the entire circuit. Circulation will continue as long as the water in the receptacle is kept warm. The substitution of iron pipe for the glass tube will in no way alter the conditions and the introduction of a radiator in the circuit will tend only to accelerate the flow by causing a greater temperature drop.

In Fig. 1 we have the condition generally met with in single-pipe work and one in which the gravity head plays but a very small part. Assume height *A-B* as 2 ft., water temperature at *A* 200 deg. and at *C* 180 deg. The available gravity head will be 0.016 ft. while the differential due to the resistance of the shunted portion of the supply main will usually range between 0.1 and 1 ft., depending upon the distance *E-F*, size of main and velocity of flow. In such cases it is well to neglect the gravity head entirely and let it take its place as a safety factor.

Fig. 3, on the other hand, presents quite a different view of the subject. Height *A-B* is now 30 ft. and the available differential due to *E-F* is 0.2 ft. With water temperatures of 200 deg. at *A* and 180 deg. at *C* there will be a working gravity head of 0.24 ft., making the circuit capable of passing a quantity of water sufficient to heat 50 per cent. more radiating surface than would be possible if the gravity head did not exist. It is not well, however, to allow the gravity head in such a circuit to greatly outweigh the differential produced by *E-F* as the circulation is liable to become sluggish with the low water temperatures used in mild weather and lead to poor heat distribution among the various radiators, especially those placed at widely varying elevations above a common supply main.

Fig. 4 illustrates a form of connection in which a careful consideration of the gravity head becomes of the highest importance. In this case it does not act as an auxiliary to the differential produced by *E-F* but as a stubborn negative force. Assume *A-B* as 15 ft., differential due to *E-F* 0.2 ft. and temperature of water in main 200 deg. Valve *X* is closed and the water temperature in the radiator and its branches is 70 deg. Valve *X* is now opened and the 0.2 ft. differential allowed to force hot water from *E* toward *B*. The descending column of 200-deg. water will move to a point *P* which, if there are no heat losses from *E-B*, will be located at a distance of about 6 ft. below *A*. Further flow will now be impossible as the difference in the weights of columns *A-P* and *C-P'* is exactly equal to the available 0.2 ft. differential. Actually there will always be heat losses from *E-B* which will lower the temperature of the water column *A-P* and gradually bring plane *P-P'* to the level of the supply tapping *B* of the radiator with a temperature of a trifle over 70 deg. at *B*. The rate of flow will be infinitesimal and the radiator will remain cold. In dealing with a case of this kind, distance *E-F*, size of main and velocity of flow must be so proportioned that the differential due to *E-F* will be sufficient to overcome the gravity head plus the frictional resistance of the circuit. This frictional resistance need not be taken as that produced at maximum flow as the opposing force of the gravity head will fall to a small fraction of its original value after flow has been established.

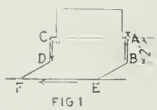


FIG. 1

FIG. 2

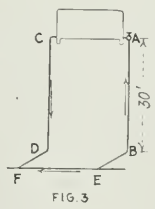


FIG. 3

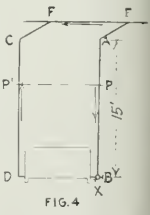


FIG. 4

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Brooklyn, N. Y.

EDITORIALS

Choice of Fuel

Certain parts of boiler-house equipment are, or should be, selected according to the character of fuel burned. The same is true of the general layout of the plant itself as well as the design of the boiler furnace and many other things directly controlled by the fuel. Therefore the character of the fuel should be determined in advance of the construction of the plant. If this cannot be done the characteristics of the several available fuels may be investigated to determine whether the choice will not narrow down to a very few varieties so that their peculiarities as a whole may receive proper consideration.

There are many different kinds of coal, but the value of any kind is measured by its capacity to produce heat, or the number of pounds of water a pound of it will evaporate as compared with its competitors. This generally should determine the choice. Often it is not easy to decide, particularly when the available coals differ widely in physical characteristics as well as in chemical composition.

For example, a long-flame coal will require a larger furnace than a short flame coal. The volatile, ash and sulphur content will materially influence the selection of equipment. Other peculiarities of coal may be of minor importance sometimes and at others be the deciding factors in determining the selection. Some of these are: the relative ability of the coal to bear transportation and rough handling, its deterioration from weather exposure, tendency to spontaneous combustion in storage, etc.

Where the plant is near enough to the anthracite fields such coal is often preferred. Then the choice is restricted to the selection of the particular kind and grade—the main issue probably being the size, pea or buckwheat. Of these two, probably the latter, if of good quality, reasonably free from slate, etc., will prove more economical than the larger size. Buckwheat generally requires more grate area to burn without forcing the fires.

Where natural gas or oil is available at a reasonable figure, it may be expedient to use one or the other instead of coal. The selection of proper boiler-house equipment is then usually easy, although not always free from complexities. Attention must be given to the probable future cost as compared with coal and to the element of permanency, or probable duration, of the supply.

Both oil and gas as fuels have their advantages and incidental economies often make them cheaper than coal, even when their cost, compared on a thermal basis, is much higher. Cleanliness and absence of dirt, smoke and ashes, are considerations as well as low labor costs and ability to raise steam quickly, maintain a constant pressure and instantly bring the plant up to its maximum capacity. On the other hand there is the risk of a permanently exhaust fuel supply or of its temporary curtailment. There is also more or less fire risk in connection with oil or gas firing, but particularly with the former when carried in storage.

As a rule where a new plant is to burn either oil or gas it should be designed and arranged so that it can be quickly and cheaply changed to burn coal.

The size as well as the location of the plant often govern the selection of fuel. If small, so that the total cost of fuel is not important, considerations of cleanliness and convenience may outweigh that of cost. If in a city or town near residences, or at industrial plants where smoke and soot are particularly objectionable, the use of anthracite coal, gas, oil or coke, all of which have merits especially commending them for use in such plants, is entirely justifiable.

Producer gas for firing boilers has received but scant consideration up to the present, possibly because gas producers apparently have not reached an efficiency and economy that would warrant such use of the gas or because its direct use in gas engines seems more logical. In a few isolated cases producer gas may be used for steaming purposes to advantage, as, for example, where the gas is made in very large quantities for metallurgical furnaces or for other purposes. In such cases it might be good policy to operate the boilers with the same kind of fuel, if the quantity required is small in comparison with the total amount produced.

Integral Boiler Shells

The introduction and development of electric and autogenous welding naturally suggest the passing of the riveted joint on boilers and other vessels under pressure. A weld may be made by either of these processes which has the full strength of the sheet, and if one could only know that this had been done, that a sheet or sheets could be joined and rolled into a perfect cylinder with no irregularity of surface, stronger than a riveted shell of the same thickness, and free from the hidden crack of even the butt-strapped riveted joint, the ideal in shell construction would seem reached.

But who shall say if the weld is perfect? A riveted joint with modern shop methods must have, initially at least, about the calculated efficiency. Drifting and sledging may impair the integrity of the material and lack of rotundity may allow continual working which may result in fracture, but one may justly feel a considerable degree of confidence that two sheets held together with well-driven rivets will require pretty nearly the calculated stress to part them. With the weld, however, it is largely a matter of faith. A little careless use of the flame and the metal is burned, its structure completely changed and its tenacity impaired; a failure to obtain a complete union, any impurities upon the surfaces, and you have already an incipient crack; and so far as is yet known there is no way to tell how good the weld is without pulling it apart.

Professor Kautny, of Nürnberg, who has done more than any other to develop the art of autogenous welding and to find new applications for it, has incurred the im-

tient criticism of the promoters of such systems and ppliances by taking a firm stand against the use of eh welding for pressure vessels until a method is deloped for proving the integrity of the weld. Some our readers may be able to suggest such a method. prize contest has developed suggestions based on elecical and heat conductivity, vibration, sound, etc. Exnsometer tests might be illuminating. Welding is being tensively and successfully used in joining fittings to eam mains, receivers, etc., in an effort to avoid joints d reduce maintenance. Who shall say how far we may in this direction?

It is physically possible to do away with the joint together, riveted or welded. The Russian Government s some boilers building the shells or drums of which e made by boring out a forging some two and a half et in diameter until only a shell of something over an ch is left. Seamless tubes are drawn up to ten or elve inches in diameter and could be drawn larger if it uld pay. Krupp got his start by rolling jointless locootive tires. He could roll cylinders too if there were demand for them backed up with sufficient cash.

The development of the steam boiler is in the direction smaller shells, making the passing of the rivet more a possibility.

⁂

The Better Attitude

An operating engineer sometimes gets the idea into s head that the "consulting engineer" is a dangerous ctor in the field of power-plant engineering. He delops a kind of vague and indefinite fear that he stands constant danger of losing his place on account of the lations of some consulting engineer with the manageent of his plant, and when the consulting engineer dertakes any tests of the plant he thinks the danger s become acute, and he fails to coöperate in the work investigation and improvement.

Nothing could be farther from the truth than this fear, d no action on the part of the operating engineer uld be more damaging or dangerous to his cause than this failure to coöperate.

Here is a story from "real life" that bears out the gument.

The engineer of a small plant within fifty miles of ew York had two boilers in service running at about lf their capacity, and evaporating a trifle more than x pounds of water per pound of soft coal having a eat value of 13,400 heat units. A consulting engineer as called in, and his expert combustion man taught the ngineer of the plant how to fire the boilers so that an tual evaporation of eight and one-half pounds of water er pound of coal was secured, thus effecting a saving of early thirty per cent. in the fuel cost.

The engineer is still on his job, happy over the imrovement made in the operation and giving satisfactory rvice because his practice in the boiler room is now line with the latest information and experience.

What would have happened to this engineer if he had iled to coöperate in this move and declined to accept structions from the expert combustion engineer? Dissal, almost certainly.

And, as knowledge of smokeless and less wasteful comstion becomes more general among manufacturers and her power-plant owners, there will be an ever increasing number of plant examinations and improvements. Engineers who have been "jogging along" at the old rate will be forced to wake up, bring their practice up to date, and live up to the new standard. Wise and progressive operating engineers will take the steps along the line of improvement in this branch of their work before their employers "get wise" and make a demand for it. The operating engineer had better make the discovery of weakness for himself, choose his own doctor and get the credit of effecting the cure, than to wait for his employer to discover it, select the physician and force the cure.

⁂

Factory Fire-Chiefship

The recent fire at Binghamton, N. Y., in which more than fifty girls lost their lives, is another demonstration that, despite the good work of various factory commissions, numerous fire traps still exist in violation of law. It is claimed that this fire did not last more than twenty minutes, yet the inflammable material of which the structure was made and with which it was littered spread the flames as rapidly as would celluloid. There will be an investigation, but what real good will come of it is difficult to even conjecture. Somebody is to blame.

In many factories, mills and office buildings the management would make the engineer chief of the factory fire department. Some factory commissions and those in charge of state supervision of factories encourage this because they appreciate that his training as an engineer well qualifies him for the duties.

This is all right if the engineer has time to care for and train the organization. Engineers who are now doing this work and those whom the management want to assume such responsibilities should make sure that they can properly care for the power plant while discharging the duties of factory fire chief.

Should an engineer take such work upon himself, let him understand that the state will hold him morally responsible but perhaps not legally so, for any serious fire in his factory. Every engineer knows how difficult it is to get the average management to purchase the labor- and money-saving apparatus for the power plant. Is it to be assumed that there will be less hesitation about putting in iron stairways, fire-doors, etc., and making more exits when the fire chief points out the necessity for such things? Should a fire break out in the meantime, causing loss of life in sufficient numbers to warrant an inquiry, will it be easy to prove that the factory fire chief did all he could to prevent it?

⁂

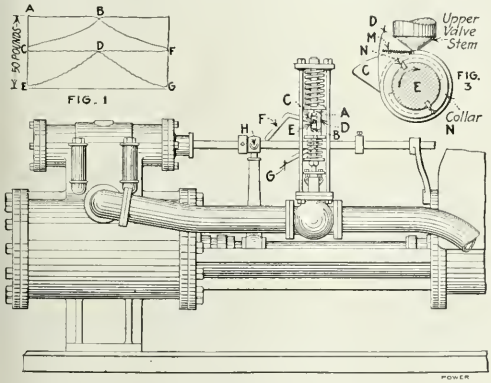
"Advantages and Applications of the Low-Pressure Steam Turbine" was the subject assigned for the Stillman prize paper, open to competition among members of this year's graduating class of the Stevens Institute of Technology. On page 220 of this issue will be found an abstract of the paper for which the prize was awarded. Our readers who are especially interested in the place which is occupied in the power field by the low-pressure steam turbine, if not instructed, will at least be entertained by the author's review of the subject. It strikingly shows the proficiency which students of a pioneer school of engineering may attain in the discussion of a broad subject of modern practice.

READERS WITH SOMETHING TO SAY

Novel Control of Steam for Pump

There have appeared lately in POWER a number of pump-indicator diagrams, which recall to my mind a method of pump control by a novel distribution of steam within its cylinder. The pump not being piped for an indicator, no diagrams can be shown, but had some been taken they would reveal operating conditions as outlined in Fig. 1. It will be noticed that a cutoff of steam is effected, and that expansion for half the stroke is shown, but the back pressure dissipates the economy.

When a new feed pump was installed in a certain plant the engineer piped the old pump to supply water to a large tank on the roof. Experiencing some difficulty in regulating it, as the steam piston was of such an area that by computation 25 lb. was sufficient pressure to operate it, he attempted to control the steam distribution by cutting off at half stroke, and compelling the piston to continue on by expansion of the steam behind it. The



VALVE FOR VARYING THE BACK PRESSURE ON THE EXHAUST FROM A PUMP CYLINDER

throttle pressure was 50 lb., being the boiler pressure lowered to the limit of a reducing valve.

Having an old 2-in. superheat valve, he piped it to the exhaust outlet, and made such changes in its exposed gear as would cause it to maintain 25 lb. back pressure for half the stroke, and thence gradually to lower the pressure to zero. He accomplished this by sawing the valve stem in two, and interposing the spool *A*, Fig. 2, which is pinned to the upper half of the stem, while allowing the lower stem to move freely a certain distance within the bore. The right pressure on the valve disk was obtained by manipulating the nut that governs the compression on the two springs shown.

Now if the spool *A* be raised slowly by hand the valve disk will retain its seat for a time, but the tension of the lower spring will be gradually relieved, and finally the disk itself will be lifted when the bottom edge of the slot in the spool comes in contact with the lifting pin *B*. This was accomplished mechanically by the use of the two cams *C* and *D* mounted on the shaft *E*. To the other end of this shaft are secured the irregularly shaped bell-crank arms *F* and *G*, which are caused to rock back and forth by the roller *H*, on the tappet arm of the pump, coming in contact alternately with each at half stroke. The shaft *E* is supported by a bearing (not shown) attached to a standard secured to the catch basin of the pump.

The operation is as follows:

When the piston stands at the end of the stroke, the position of the parts of the device is as shown in the sketch. The valve carrying the auxiliary piston has opened the steam port, and the exhaust is free to leave the cylinder. But as the improvised back-pressure valve is closed, only an amount such as will reduce the exhaust pressure to 25 lb. can escape. During the first half of the stroke the piston is moved by a motive pressure of 50 lb., against a fluttering counter-pressure of 25 lb., which leaves 25 lb. as the effective pressure.

At the half-stroke position the steam valve closes and the roller *H*, engaging with the arm *G*, starts to rock the shaft *E*. If two indicators were in use the lines of the diagram (Fig. 1) recorded thus far would be *EA* (admission), *AB* (steam) and *CD* (back pressure). From this middle point the steam expands and the expansion line *BF* is described. Likewise, as the shaft *E* is rocked, and the cam *D* in consequence lifts the spool and gradually relieves the pressure on the valve disk, the back pressure is lowered, and the apparent expansion line *DG* is formed. Thus theoretically there exists an effective pressure of about 25 lb. throughout the stroke.

The shape of the cams is such that just as the tappet arm of the pump strikes the tappet the back-pressure valve closes quickly, and the cams assume the position shown in Fig. 3.

On the return stroke the conditions are the same—the roller on the tappet arm then comes in contact at half stroke with the rocker-arm *F*, and the cam *C* now relieves the back pressure, while the cam *D* returns to its starting position by the action of the small spring *M* (Fig. 3), which connects it to the setscrew of the collar. The dotted lines running from the keys *NN* indicate portions cut off the cam to allow of this return.

R. O. RICHARDS.

Framingham, Mass.

❖

Burning Crude Oil

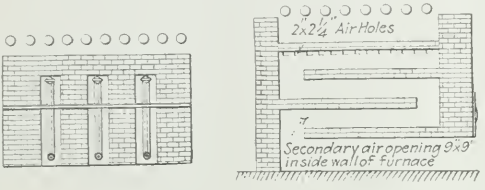
I have read articles describing various methods of burning fuel or crude oil, but have never seen anything resembling the method used in the plant where I am employed, which contains four 250-hp. water-tube boilers. One is out of service most of the time for washing, on account of bad water, leaving only three boilers available for constant service. These must develop up to 225 per cent. of the rated capacity to handle the load,

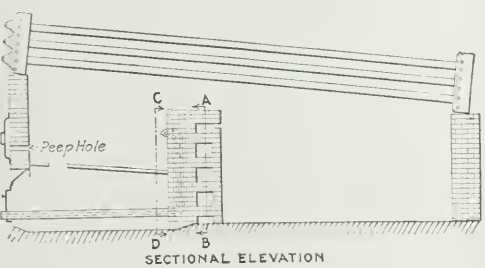
which at times drops to the normal rated capacity of the boilers.

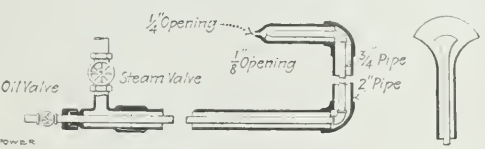
After trying out different furnaces and burners with various degrees of success, but still being unable to get the required amount of steam without making black smoke, the outfit shown in the accompanying illustration was devised and installed.

The burners are composed of a $\frac{3}{4}$-in. oil pipe inclosed in a 2-in. steam pipe, steam being used to heat, vaporize and atomize the oil during its passage through the heater-burner, which extends from the front of the ashpit, back through the same, and up through openings in the bridge-wall to a point about midway between the slightly inclined grate level and the boiler tubes.

Steam gathers the vaporized oil as it is discharged from the oil nozzle and hurls it toward the front of the fur-







DETAILS OF FURNACE AND OIL BURNER

nace where it meets a supply of air coming up through 4x6-in. opening in front of each burner left in the door of the furnace. This air, however, is not sufficient to produce complete combustion; therefore a secondary supply is afforded through the hollow bridge-wall, shown in section *AB;* this air supply is regulated by a hand damper.

In passing the secondary air through the bridge-wall as often as possible before releasing, it is brought to the highest possible temperature, thereby instead of cooling the gases coming to the combustion chamber, it mixes with and ignites with all the unburned gases.

It is possible to run with very low stack draft, giving a low gas velocity, which contributes largely toward a low stack temperature, high CO_2 and consequently greater efficiency at heavy overloads.

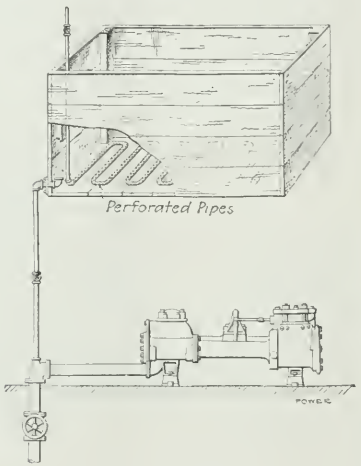
Pittsburg, Kan. B. W. BABCOCK.

Feeding Compound to Boilers

For the best results, boiler compound should be introduced regularly and systematically instead of at infrequent intervals. If introduced only when the boiler is shut down, not only are the periods between treatments too long, but much of the compound is blown out of the boiler in the course of ordinary running, long before a new charge is introduced.

To avoid this condition the best method is to use some form of continuous feeding apparatus so that the compound can be put in at any time and in any reasonable quantity. Small quantities injected daily accomplish the best results and avoid foaming. It is better to put in a pound a day regularly, than 20 lb. and then wait ten days and "give another dose." Some means of introducing the compound into the feed water as it goes to the feed pump are best. For this purpose we use the outfit illustrated.

Supported by brackets on the wall of the boiler room about 4 ft. above the pump is a wooden tank 4x8x4 ft.



OUTFIT FOR FEEDING COMPOUND TO BOILERS

in which the compound is mixed with water and is kept warm and agitated by a $\frac{3}{4}$-in. steam line feeding a coil of perforated pipe on the bottom of the tank.

In one corner of the tank near the bottom is a 1-in. line with an elbow turned up inside of the tank and connected to the drip ell on the suction side of the feed pump. In this 1-in. line there is a valve for regulating the supply of compound to the boilers. This method has worked with success since its installation and is feeding compound to nine 250-hp. water-tube boilers.

C. E. ANDERSON.

Chicago, Ill.

[There is no question of the truth of the first statement in the above letter. Compound manufacturers advise the continuous feeding wherever possible and common sense indicates the advantage. The device described is one of the simplest and most evidently satisfactory home-made schemes that has come to our attention. We shall be glad to hear from readers who can suggest any improvements on this arrangement.—EDITOR.]

QUESTIONS BEFORE THE HOUSE

Why Vacuum Is Not Higher

W. H. Shew, in the June 17 issue, page 867, fails to state the amount of steam that the surface condenser is to handle or the steam consumption of the engine. Either of these data would assist greatly in discussing the low vacuum obtained. Considering the given information, it is apparent that the condenser is too small to handle all the exhaust from the engine. Besides having the tubes well packed, the condenser should be subjected to a water pressure of about 20 lb. to test for leakages by the tubes. The fact that the condensing water leaves at 90 deg. F. shows that ample water is supplied to the condenser.

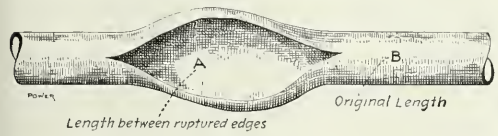
Usually the intake of a surface condenser is at the top and the discharge at the bottom to allow for a complete travel of the water in one direction and back before leaving the condenser. The size air pump used in connection with the condenser should be stated, as it is possible that the vacuum pump is not large enough to take care of the condensed vapors.

THE DEANE STEAM PUMP CO.

Holyoke, Mass.

Boiler-Tube Failures

An account of an accident to a boiler in a New York hospital is given on page 40 of the July 1 issue. Some of the conclusions drawn from this accident are apparently incorrect, and may mislead some readers in their attempt to arrive at the cause of other accidents of a similar nature. The account states that the rip in the tube was 12 in. long and 8 in. wide, and then goes on to say that it was undoubtedly due to a defect in the tube, as it was thin where it ripped. The article then states that it appears that the tube could not have been overheated as there was plenty of water in the boiler and there was no scale in the tube, even beyond the ripped portion.



RUPTURED BOILER TUBE

While it is risky to give an opinion regarding the cause of any accident without having seen the parts, still the evidence in this case is pretty strong that the cause of the accident was overheating, due to scale. The fact that no scale was found in the tube does not alter the case, because an accumulation of scale at the affected point may be the cause, and even if the tube should be generally scaled, the disturbance to the tube at the time of the accident would shake it all loose and the outrush of steam and water would be certain to carry it out of the tube. I have seen many tube ruptures, and never in my experience have I seen a rupture of the extent of the one in question, where any considerable amount of scale was retained in the tube. The thinning of the edges of the tube at the point of rupture would indicate that overheating was the cause of the trouble, because in such cases the edges are nearly always pulled down to a knife edge.

Practically the only way to tell if a boiler tube has been ruptured, due to poor material or to thinning down to a point where it is no longer capable of resisting the pressure, is to measure the circumference of the tube at the rupture, or to measure what was the circumference at the instant of failure, and by comparing this measurement with the original circumference of the tube, the fact as to whether the tube has actually increased in circumference or not can be determined. A tube that has failed on account of imperfect material or a gradual thinning down, will usually measure the same diameter at the point of rupture as it would at any other point.

The figure will show how the measurements mentioned are to be taken, and if the measurement *A* (length of metal, not space, between the ruptured edges) is more than that at *B* the tube has been stretched in circumference in rupturing, and such stretching usually denotes overheating as a cause of failure. Of course, a thin edge due to general corrosion of the tube and one due to the metal pulling down in the act of rupturing, should be apparent to the eye, and the appearance of the surfaces of the tube at the rupture will also usually tell if overheating of the metal has played a part in causing the accident.

J. E. TERMAN.

Hartford, Conn.

New Features in Pillow-Block Design

I note in the May 27 issue that Mr. Campbell recommends a new type of pillow block. From a study of his sketch the idea does not appear to be feasible. The main reason being that usually modern engines do not have the pillow block bolted to the frame, but cast solid in one piece and of such shape that it would not be possible to use wedge bolts on the back side as he suggests. Another reason is that there would be likelihood of misadjustment which would very likely cause hot bearings. In taking down the bearing of the ordinary engine as built at the present time the top cap is taken off, and the wedge bolts which usually go through the cap are removed. Then the wedge is taken out, after which the front quarter box can be pushed back, and rolled around to the top of the shaft. To get the back quarter box out, the shaft is pushed ahead and the flat plate back of the box taken out. Then the back quarter can be removed as the front one was. If wedge bolts were used as suggested, it would be necessary to turn them back to get the box out, and it would be hard to get them readjusted as they were before, and the shaft would be thrown out of alignment.

As usually designed the wear of the boxes does throw the shaft out of alignment, but ordinarily at the end of

ix months or a year it will not be over a few thousandths f an inch out, and a very thin liner is required to put back in place. This variation gives little trouble in the rank-pin brasses, as they must be given some clearance. n 10 months' run our 19x18-in. medium-speed engines ore only enough to make 0.012 in. difference between the wo planed alignment spots on the inside of the frame nd the end of the crankpin.

There is, however, another idea that is applied by one r two builders of large engines that might have some erits, and, that is to use a wedge adjustment under the ottom quarter of the main bearing. This provides means hereby the shaft may be leveled. With large direct-onnected generators with small air gaps this feature ight save the work of rebabbitting the bottom shell for ome time.

One thing is certain, and that is, that we already have oo many novelties in the designs of engines, many of hich have little merit to warrant their adoption. Each uilder adds some special feature; in one it may be in the overnor, in another in the valve-gear, connecting-rod nds and bearings, crosshead, oiling system, and so on hich does not make the engine more economical or less xpensive but sometimes makes more trouble for the en-ineer, and puts a monopoly on repairs.

J. C. Hawkins.

Hyattsville, Md.

Governor Design

Forrest Allen in the July 1 issue states that a belt on large cross-compound Corliss engine broke while the ngine was carrying full load. On starting the engine fter the belt had been repaired the flywheel was noticed o be running considerably out of true. Examination howed that every bolt holding together the halves of the im was sufficiently loose to allow the nuts to be turned y hand. The conclusion was reached that the bolts had een stretched, due to the centrifugal force of the wheel hen the load was suddenly thrown off. Mr. Allen con-ludes by stating that: "With a 20-ft. flywheel it would e interesting to have the flywheel designer and the gov-rnor expert hand us a few figures, showing how long efore the flywheel reaches the bursting speed, does the overnor check the speed of the wheel, when full load is uddenly thrown off."

It is probably impossible to design a governor that ould operate to perfection under such conditions. If a overnor were designed to operate within 1 per cent. it ould not eliminate the danger mentioned, because under onditions of sudden release of load the speed of the wheel ven if it were only for a fraction of a revolution would e dangerous.

With large flywheels there are always two conditions o be reckoned with; the throwing on suddenly of a heavy oad has the tendency to suddenly retard the rim speed. he throwing off suddenly of load has the opposite or an ccelerating effect. The result is that terrific strains are et up in each case between the rim and the hub. These trains, due to acceleration, or *vice versa*, may occupy nly the fraction of a second. They act as a jerk on the heel.

John F. Hurst.

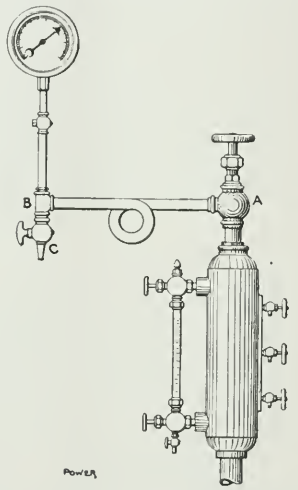
Louisville, Ky.

Plugged Steam-Gage Pipes

I have experienced the same trouble as told by Mr. Sedingers in the June 24 issue. Three steam gages were connected to the top of three water columns with a 3/8-in. elbow running at right angles to another 3/8-in. elbow below the gage, and as no valve intervened it was necessary to shut off both steam and water valves to the water column in order to remove the gage.

In getting up steam on my first Sunday morning after an hour of ordinary firing, the gage on boiler No. 1 registered 95 lb., that on No. 2, 40 lb. and that on No. 3, 75 lb. As all the boilers were connected to a common 10-in. header and all the stop valves were wide open, I surmised where the trouble was.

Shutting off the pressure from the gages and removing them I found each clogged with a pasty sediment



Connections to Prevent Plugging of Steam Pipe

of the consistency of stiff putty that required scraping and boring to remove. After cleaning the gage pipes thoroughly I replaced the gages, putting 3/8-in. angle valves at *A*, where there had previously been an elbow, and a 3/8-in. tee at *B*, with a pet-cock at *C*. The angle valve permits of cutting out any or all gages without interfering with the water columns, and the pet-cock *C* permits of a daily blowing out of the gage pipe which is as clear today after six years of constant use as when first installed.

I next turned my attention to the pop valves and found the pop valve on boiler No. 1 would blow readily at 118 lb. and all the strength of two men on the lever could not induce even a "leak" of the valves on boilers Nos. 2 and 3. Removing these two valves from the boiler and taking out the springs, it required the blows with a 12-lb. sledge against a block of wood to drive the valves off the seats. The guides were so completely "frozen" that it required steel scrapers to remove them.

John P. Short.

New Orleans, La.

INQUIRIES OF GENERAL INTEREST

No Lap Engines—What engines have no lap?

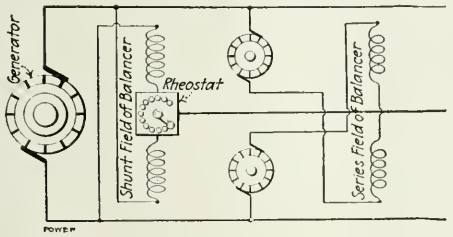
J. M.

No lap is given the steam valves of steam pumps or of engines in which steam is taken for the full length of the stroke, i.e., where steam cannot be used expansively.

Three-Wire System—What are the proper connections for a three-wire system employing one generator with a balancer?

A. H. A.

The proper connections are given in the following diagram:



Shunt-Wound Dynamos in Parallel—We have a shunt-wound dynamo installed and are considering installing another. Will there be any difficulty in operating them in parallel?

H. B. S.

Not if their characteristics are the same. If the voltage drop as the load increases is not alike in both, the greater share of the load will go to the dynamo with the smaller internal drop. To prevent it being overloaded, then, some resistance will have to be put in its armature circuit to equalize the per cent. of voltage drop.

Feed-Water Temperature—In making an evaporative test of a boiler where should the feed-water temperature be taken, at the feed-water heater, where it is less than 212 deg. F., or at the economizer, where it is more than 212 deg. F.? In one case the comparative rate would be greater than the actual, in the other it would be less.

A. H. F.

In the evaporative test of a boiler where an economizer is used or any other method of heating the water before it is fed to the boiler, account is to be taken of the temperature of the water as fed; that is, the temperature should be taken where the water is fed into the boiler. In any event the heat thus delivered to the boiler is to be deducted from the total heat of the steam at the pressure and temperature of evaporation.

Chimney Proportions—Is a chimney 90 ft. high and 5 ft. 6 in. in diameter correctly proportioned, or should it be higher for this diameter?

R. H. R.

The proportions of diameter and height are purely a local consideration. Chimneys are rarely built less than 80 ft. high and a 5½-ft. diameter chimney is usually made 100 ft. high. For a given diameter of flue the draft capacity is as the square root of the height. By the ordinary rating a chimney 5 ft. 6 in. in diameter and 90 ft. high would have a capacity for about 660 b.hp. while 100 ft. high its capacity would be 694 b.hp. It was likely considered more economical and safer against wind pressure to build the chimney only 90 ft. high. Had it been 100 ft. high it could have been made 5 ft. 4½ in. in diameter and still had the same capacity.

Estimating Coal Cargoes—How can the quantity of coal in a coal barge be determined? Also the quantity in an irregular-shaped coal pile?

E. L.

The coal contained in a boat is estimated from the weight of water displaced. The volume of water displaced from one water line to another being estimated in cubic feet, according to the shape and dimensions of the boat, the weight producing such a displacement is found by multiplying the number of cubic feet of displacement by the weight of one cubic foot of water, 62½ lb., and dividing by 2240, to get long tons, or 2000, to get short tons of loading which produced the displacement. The weight of coal in a hold can be estimated also by finding the volume of coal in cubic feet and dividing by the volume of a ton. A long ton, 2240 lb., of bituminous coal takes up a space of 41 to 45 cu.ft. and of anthracite coal, 34 to 41 cu.ft. To find the number of tons in a given pile or space, divide the cubic feet of space occupied by the cubic feet per ton.

Methods of finding the volumes of various shapes are given in the Engineers Study Course, Mar. 11, 1913, issue of "Power," page 354 and pages 392, 430 and 468 of issues to that of Apr. 1, 1913.

Steam Backs Up—If, on a tandem-compound engine, a by-pass between the high- and low-pressure steam chests be opened while the engine is running, allowing steam at boiler pressure on both valves; would this steam in the low-pressure chest blow through the receiver and into the high-pressure cylinder when the ports of the latter were open for exhaust?

E. R. M.

Yes. Not only that, but steam would actually be pumped backward through the high-pressure cylinder into the steam line if the exhaust valve were set for any compression at all. Tracing the cycle through, steam is admitted in the high-pressure cylinder at boiler or line pressure up to cutoff. At the end of expansion, when ordinarily release takes place, the back pressure will be higher than the pressure in the cylinder (in fact will be line pressure) hence steam will flow from the low-pressure steam chest through the receiver into the high-pressure cylinder. As the piston returns on its stroke some of this steam will be driven back into the receiver, but as soon as the exhaust valve closes for compression no more steam can escape. This steam then will be compressed until the admission valve opens and then, being at much higher than boiler pressure, part will escape into the supply line until the pressures equalize. This action would be repeated on every stroke and no useful work would be done by the high-pressure cylinder. In fact it would become a compressor.

Butterfly Valve—What is a "butterfly" valve, how is it constructed and where is it used?

G. C. W.

The original application of the name was to a valve consisting of a pair of flap valves placed back to back. Sometimes they are made of one piece of leather fastened down in the middle and often known in English practice as a "butterfly clack." When made of a flexible material like rubber, canvas or leather, the chamber of the valve should be of considerably greater diameter than the valve and the latter should rest when closed on a flat horizontal grating or on a plate perforated with holes to which it is fastened down at the center, being left loose at the edges. To prevent the valve from rising too high, it usually has, as a guard, a thin metal cup formed like a segment of a sphere, grated or perforated like the valve seat to which it is bolted at the center, serving also to fasten the valve down at that point. Such butterfly valves are used on air pumps where they are frequently made with the flexible material reinforced. They are sometimes known as "bucket valves" when used on the piston of a wet-air pump. "Butterfly" forms of valves are frequently used on steam lines or passages for reducing or almost completely cutting off the discharge, in which case the valves are made of metal and usually have a composition seat. Nowadays, the term is more commonly applied to a damper valve which is simply a valve like a stove-pipe damper, consisting of a disk revolving on an axis through its diameter. It is used for quick but not absolute closing of a steam line.

ENGINEERS' STUDY COURSE

Draft and Its Measurement

In a natural-draft plant the chimney plays a far larger art than is commonly suspected in determining whether perating results are to be satisfactory or not. A chim-ey which is too small means poor draft and sluggish mbustion with all its attending annoyances and losses. chimney which is too large means waste of money in st cost and, often, loss due to excess air. Consequently, is fitting that a few points about chimney design be ken up at this juncture.

Natural Draft

Before the actual formulas for figuring chimney sizes itable for certain conditions are studied, it is well to t a thorough understanding of the principles of natural aft.

This old earth is entirely surrounded by an ocean of gas mixture called air. The depth of this ocean is not nown, but is estimated at all the way from 50 to 500 iles. As we transact most of our business at the bot-m of this ocean we do so under a normal pressure, due the weight of the air, of 14.7 lb. per sq.in. at sea level. s we get above sea level, naturally the pressure decreases cause there is less air above pressing down.

The volume of all gases, air included, is greatly in-nenced by change in temperature or pressure. With in-ease in temperature the air expands, that is, the volume creases. With increase in pressure the volume dimin-hes. These changes in volume, due to changes in tem-rature or pressure or both, take place according to well nown laws. Hence, if the volume of given weight of a s at a given temperature and pressure is known, it is ossible to figure exactly what the volume would be at me other temperature and pressure.

For every ordinary purpose we may take the atmos-neric pressure (at or near sea level) as 14.7 lb. per sq.in., though actually the pressure is constantly varying slight-, due to changes in the condition of the air. As natural aft has to do with air at atmospheric pressure only, and we have decided to consider this pressure as being xed at 14.7 lb. per sq.in., there remains only one vari-ble—temperature—to consider during the study of the resent subject.

Absolute Temperature

With the pressure remaining the same the volume of a ven weight of air increases or decreases $\frac{1}{492}$ of its vol-me at 32 deg. F. for every increase or decrease of 1 deg. its temperature. For instance, if a pound of air at mospheric pressure and 32 deg. F. has a volume of 2.39 cu.ft., at 100 deg. F. (the pressure remaining the me) its volume will have increased by

$$12.39 \times \frac{100 - 32}{492} = 1.71 \ cu.ft.$$

ence, its volume at 100 deg. would be

$$12.39 + 1.71 = 14.1 \ cu.ft.$$

This law holds good for all temperatures dealt with in steam power-plant work. If it held good for all possible temperatures, that is, if a gas continued to shrink $\frac{1}{492}$ of its volume at 32 deg. F. for every degree drop in temperature, when the temperature dropped the 32 deg. from the freezing point to zero and then dropped 460 deg. below zero, thus dropping a total of

$$460 + 32 = 492 \ deg.$$

the gas would disappear entirely. Such low temperature has never actually been attained; hence, we do not know whether or not a change in the law takes place, but it is quite certain that one does.

As a result of the above law governing the expansion and contraction of gases through change in temperature an imaginary standard for temperature has been invented, which is convenient to use when solving problems dealing with gas temperature and volume. Temperatures expressed according to this standard are known as absolute temperatures. The zero according to the absolute scale is 460 deg. below the zero on the Fahrenheit scale. Hence, the absolute temperature of any gas is its Fahrenheit temperature plus 460.

For instance, the absolute temperature of a gas at 92 deg. F. is

$$92 + 460 = 552 \ deg.$$

The convenient thing about these absolute temperature units is the fact that where the pressure remains the same the volume varies in direct proportion to the absolute temperature.

To illustrate, if the volume of a gas is 14 cu.ft. per lb. at one temperature, say, 60 deg., and it is desired to estimate the volume at some other temperature, say, 109 deg., the pressure being the same in each case, it is simply necessary to multiply by the ratio (expressed as a common fraction) of the two absolute temperatures. The absolute temperature corresponding to 60 deg. F. is 60 + 460 = 520 deg., and that corresponding with 109 deg. is 109 + 460 = 569 deg. Hence, the volume at 109 deg. would be

$$14 \times \frac{569}{520} = 15.31 \ cu.ft.$$

The following simple formula gives the pressure, volume or temperature of one pound of air when any two of these factors are known

$$Pv = 53.37 \ T$$

where

P = Absolute pressure in pounds per square foot;
v = Volume in cubic feet of one pound of air;
T = Absolute temperature of the air in degrees Fahrenheit.

Transposed to the form most convenient for calculating volume the formula is written thus

$$v = \frac{53.37 \ T}{P}$$

To apply in a practical problem, assume it is desired

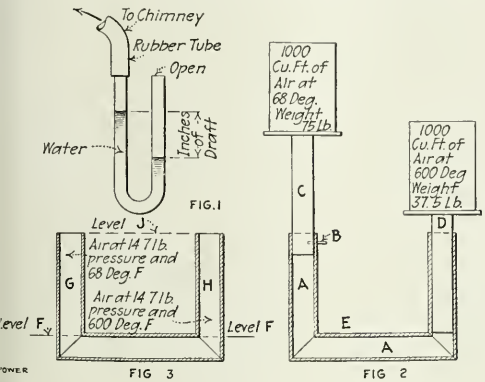
te figure the volume of a pound of air at atmospheric pressure (14.7 lb. per sq.in.) and 70 deg. F. The absolute temperature corresponding with 70 deg. F. is 70 + 460 = 530 deg. The pressure per square foot in the present example is 14.7 × 144 = 2116.8 lb. Then, substituting these values in the formula, we have

$$v = \frac{53.37 \times 530}{2116.8} = 13.36 \text{ cu.ft.}$$

Measurement of Draft

Draft, whether mechanical or natural, is measured by a draft gage and usually expressed in inches of water similarly to a vacuum, except the latter is expressed in inches of mercury.

The simplest form of draft gage is a U-shaped tube of ordinary glass, as in Fig. 1, and is usually fitted with a scale in inches and decimal fractions of an inch. One



eg of the tube is connected with the furnace, flue, chimney, or other place where the draft is to be measured, nd the other leg is left open to the atmosphere. The draft is the inches of difference in level between the water in the two legs as indicated in the figure.

There are numerous other forms of gage, most of which re designed to give more accurate readings for small ariations in draft than the one shown, but the principle f construction and the unit of measurement are the ame.

Principle of Draft

Probably every reader understands the underlying principle of natural draft in a general way, but some may e a little confused as to how the height of chimney and emperature of gases affect intensity of draft. So, to nake this basic theory quite evident to all, a little space vill be given it at this point.

Imagine a pair of frictionless and sensitive plunger cales, as in Fig. 2, located in an absolute vacuum. The onnecting tube *A* is filled with some frictionless and reightless fluid. Next, imagine that 1000 cu.ft. of air t some ordinary atmospheric pressure and temperature, ay, 14.7 lb. per sq.in. and 68 deg. F., were wrapped up n a bundle and placed on the platform of one plunger nd 1000 cu.ft. of air at the same pressure but at a temerature of 600 deg. F. were done into a similar bundle nd placed on the other plunger platform.

The weight of the 68-deg. air would be 75 lb. while that of the 600-deg. air would be 37.5 lb. or just one-half that of the former. The cooler air being 37.5 lb. heavier than the warmer, if the pin *B* were withdrawn, plunger *C* would tend to sink and plunger *D* to rise, due to the 37.5 lb. difference.

Now, assume that the plungers *C* and *D* are removed, as in Fig. 3, and that leg *G* is filled down to the level *F* with 1000 cu.ft. of air at 14.7 lb. pressure and 68 deg. F. and leg *H* to the same level with air at the same pressure but at a temperature of 600 deg., the top of both legs being open.

If each leg is 100 ft. high above level *F*, the inside area of each must be 10 sq.ft. or 1440 sq.in., and the pressure per square inch at level *F* in leg *G*, due to the weight of air in the leg, must be 75 (weight of 1000 cu.ft. of air at 14.7 lb. pressure and 68 deg.), divided by 1440; which equals 0.052 lb. per sq.in.*

Similarly, the pressure at *F* in tube *H*, due to the weight of the air at 600 deg., must be

$$37.5 \div 1440 = 0.026 \text{ lb. per sq.in.}$$

Thus, there is a difference in pressure in the two legs at level *F* of

$$0.052 - 0.026 = 0.026 \text{ lb. per sq.in.}$$

with a consequent tendency of the air in leg *G* to flow into leg *H* and push out the lighter air in the latter.

Now, if the vacuum be destroyed and the tube be submitted to the ordinary atmospheric pressure (say, 14.7 lb. per sq.in. at level *J*) the tendency of the cold air in leg *G* to force out the hot air in *H* will be just as strong as it was in the vacuum. This is true because the pressure at level *F* in leg *G* is 14.7 lb. per sq.in. (the atmospheric pressure at level *J*) plus the weight of the air contained in the leg, divided by the square inches of area of the tube, thus

$$14.7 + \frac{75}{1440} = 14.752 \text{ lb. per sq.in.}$$

Similarly, the pressure at level *F* in tube *H* is

$$14.7 + \frac{37.5}{1440} = 14.726 \text{ lb. per sq.in.}$$

Hence, the tendency of the cold air in *G* to push out the hot air in *H* is the same as under the former conditions, the difference in pressure being the same

$$14.752 - 14.726 = 0.026 \text{ lb. per sq.in.}$$

Now, as the pressure and temperature of the air outside the tube are identical with those of the air within leg *G*, this leg performs no useful function and may be dispensed with, when we have left a natural-draft chimney.

Thus, we see that natural draft is due to a difference in pressure due to a difference in weight between two columns of gas of equal height. And as the outside pressure (the atmospheric pressure) acting on these two columns is equal for any given height, this difference in weight depends upon the difference in temperature. As the pressure due to the weight of a column of fluid depends only upon the height of the column and the weight

*This method of calculating the pressure due to the weight of a fluid is used simply to make the description more clear. If the legs were not absolutely uniform in sectional area throughout their height this method would cause error. It should be remembered that the pressure due to the weight of a liquid or a gas depends only upon the vertical depth from the surface of the fluid to the point under consideration and the weight of a unit volume of the fluid. The size and shape of the containing vessel have nothing to do with the pressure.

of a unit volume of fluid, and not upon the cross-sectional area nor the shape of the column, the intensity of draft is proportional to the height of the chimney above the fire.

To sum up, then, the intensity of draft depends upon the height of the chimney and the difference in temperature between the outside and the stack gases.

The following formula may be used to estimate the intensity of draft to be expected from a chimney under given conditions.

$$D = 0.52\ H \times P\left(\frac{1}{T} - \frac{1}{T'}\right)$$

where

D = Draft in inches of water;
H = Height of chimney above grates in feet;
P = Atmospheric pressure in pounds per square inch;
T = Absolute temperature of the outside air in degrees;
T' = Absolute temperature of chimney gases in degrees.

Thus, with a chimney 175 ft. high above the grates in which the gases are rising at a temperature of 560 deg. F. when the outside air is at 60 deg. and the atmospheric pressure at 14.7 lb. per sq.in., the draft would be

$$D = 0.52 \times 175 \times 14.7\left(\frac{1}{520} - \frac{1}{1020}\right)$$

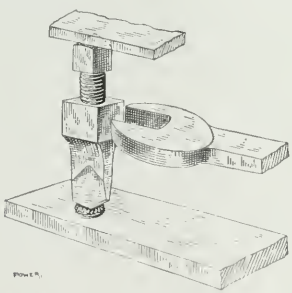
$$D = 0.52 \times 175 \times 14.7 \times 0.00094 = 1.26\ in.$$

⁂

Engineers' Handy Drill

By J. G. Koppel

Every engineer of experience will appreciate the value of a drill that will enable him to drill out broken set-screws, pins, etc., in places where an ordinary ratchet drill cannot be used without dismantling much of the



A Home-Made Drill for Narrow Places

engine, pump, etc. The drill shown may be made at the plant and by having a few of different diameters and lengths on hand many emergency repairs may be quickly made that would otherwise necessitate much time and labor.

⁂

When natural gas is used as fuel under a steam boiler from 40 to 60 cu.ft. per horsepower-hour will be required, while the same power can be developed by the consumption of from 9 to 15 cu.ft. in a gas engine, so the use of gas under steam boilers at power plants is not to be encouraged, if, indeed, it should be permitted.—"Compressed Air Magazine."

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Everything has its day, remarks "Leslie's Weekly." Now it's the oyster—Oyster Week. California has its Prune Day, Colorado its Melon Day, Washington its Apple Day. Vive le bivalve! From the oyster comes the pearl, and as the kid said: "Me sister got a diamond outer a lobster!" Every day is lobster day.

⁂

Speaking of shell fish reminds us that tripe was once a luxury, and terrapin was food for negroes. Now they've changed places. Our authority is a catalog of public documents. To tell the honest gawdstruth, we wouldn't know a terrapin if we met it face to face. As for tripe, it may be all right for those who can get it on the wing, shoot it in the leg, pluck it while it's warm, trap it, or— Say, what kind of a bird is a tripe, anyhow? We forget!

⁂

On July 12 there was a snow-bank 10 ft. deep in the Oregon Roads, near Hood River. If you can bring your imagination to bear on this scene, it may help lower your temperature during the hot spell. Remember, he who is without imagination is but a dull clod at the best. Don't be a clod!

⁂

"For my part," says a writer in the "Saturday Evening Post," "I am willing to put my money on a human being who has time for a kind and generous word for another human being once in a while." While this sentiment is as old as pagan philosophy itself, it's fine, solid stuff. If you have heretofore shied at its acceptation, try it a couple of times. It's a bully bet!

⁂

The weather plant in Washington has a new chief. Mr. Moore, of few "endearing young charms," having been deposed, Mr. Marvin now turns the engine over. No engineer has a more thankless job or so many ungrateful consumers. Everybody takes a hack at this hackneyed subject, the weather, and nobody seems satisfied. Just at this moment, if Chief Marvin would lick Gen. Humidity, he could be elected President of Mexico by unanimous vote—which never has happened in Mexico yet.

⁂

Advance, Electricity! This time it's a brush that removes the barnacles from the hulls of vessels without drydocking them, meaning the hulls. The motor is placed in watertight casings. Suggest that it is applicable as a shampoo for some of those people who are sporting mental barnacles that now impede their progress.

⁂

"Mrs. Lasalle Stoops," says "Leslie's Weekly." Our contemporary says more than this. Mrs. Stoops (Lasalle is the lady's first name) is the general manager of the Stuttgart (Ark.) Electric Light Co. We have no right to even insinuate that this enterprising lady is of suffragette persuasion. If she is, it's a big compliment to those ladies who would exercise men's prerogatives.

⁂

The immortal George W. fell out with his daddy over a cherry tree; George Wallace, mechanical engineer of the Racine Water Co., reversed this order and allowed the tree to take a fall out of him. You see, he had a crazy idea (got it on Asylum Ave., probably) that he needed a vacation. Then he went to Waukesha to visit his mother.

That dear old lady, wishing in her declining years to say she once saw George working, set him to picking cherries. He, of course, climbed the tree (he will sit down when he works). Soon he fell down and out into the yard of two old maids next door.

Later, the local Sawbones, George says, "sat on my remains. He found he could save me by wiping a joint where three ribs were broken; where I broke the Ten Commandments was a total loss."

G. W. writes he's now as normal as he ever will be, and hopes that "Power's" staff (excepting Billy Spills) will never suffer a like harrowing experience. Why this exception, George? When "cherries are ripe" for Billy, he'll try to fall in the yard of one nice young maid; not two old ones. We're right fond of Geordie Wallace, and why he wants to push us off the tree is beyond our ken.

Power-Plant Vibration and Methods of Isolation

By Francis H. Davies

SYNOPSIS—Nature of vibration and its transmission through soils of varied character. Different kinds of isolating material to absorb vibration.

The causes of engine vibration are often obscure, and the remedy, if it necessitates structural alteration of the engine, is generally expensive and none too certain in its effect. Considerable sums of money have been wasted in abortive attempts to cure vibration by balancing or the elimination of some radical fault in design; hence engineers have for some time directed attention to methods of isolation which, while permitting the engine to vibrate, prevent the spread of the disturbance by absorbtion. For many cases isolation of this kind is quite effective, but it is an easy matter to waste money by the use of the wrong material or by incorrect application.

Transmission of Vibration

It would be out of place here to enter into the very complicated question of the causes of engine vibration; but to apply isolating material correctly it is essential to understand in what manner vibration is transmitted, and how various types of engines differ in the amplitude and direction of the disturbances they set up. In no class of engine or machine is vibration of a simple nature, that is to say, entirely in one definite direction. All unbalanced parts tend to occasion vibration, but it is safe to assume that according to class, certain disturbances will predominate sufficiently over the remainder to make them characteristic of the particular type of engine; thus, the principal vibrations set up by a vertical engine are in a more or less vertical direction, while those of a horizontal engine are chiefly in the horizontal plane. In addition, both classes are subject to a tilting oscillation, which with some engines of the vertical type is very marked.

Complications are apt to arise where two or more engines are located on a common foundation block or in close proximity to one another, since their vibrations will occasionally synchronize, even though their speeds are very different. This will result in more or less regular periods of maximum vibration followed by periods of quiet; a phenomenon which has frequently been noticed and recorded by investigators of particular cases. Synchronism will occur more frequently with high-speed engines than with low speed; but it must not be inferred from this that the former are more likely to give rise to vibration trouble. As a matter of fact, the low-speed engine is more to be feared in this respect, as the disturbances it creates, although less frequent, are of greater magnitude than those of the high-speed engine and more noticeable and objectionable.

It is clear that isolation of vertical vibrations is a more difficult matter than that of horizontal. As regards the latter, a small space left around all four sides of the foundation block will help matters, as horizontal vibrations can then only take effect through their shearing action on the soil under the foundation. Vertical oscillations, however, are different, and act directly on the subsoil through the part it is most difficult to isolate, namely, the base of the foundation. If the sides of the block are in contact with the soil, vertical vibrations will also be communicated by the shearing effect above mentioned, but their intensity will not be so great since the effort of shearing will absorb or damp a good proportion of the disturbance.

The original amplitude and direction of vibration may be considerably modified in its passage through the soil. Normally, the waves may be said to spread out more or less uniformly from the center of disturbance, gradually becoming less marked and finally dying away altogether. The foundation itself absorbs, as it is meant to do, much of the vibration, and the remainder is gradually dissipated in the adjacent soil. Everything, however, will depend upon the nature of the soil, which if variable, may produce complex effects. Rock or very wet unstable soil will conduct vibrational disturbances to a surprising distance; while, on the other hand, good, dry gravel or sand absorb them and act as most efficient insulators. It is, therefore, evident that where a soil is of a composite nature, composed of well defined veins of rock or soil of different classes, the disturbance may travel farther in certain directions than in others, and give rise to vibrational effects in one or more particular spots at a distance while the intervening space is quite free from any discernible disturbance. Reflex waves provide a further complication, since by their means the disturbance may be enhanced in certain places and diminished in others in a way that at first sight it is difficult to understand. Altogether, it will be seen that the transmission of vibration through the soil is often a very complicated matter which necessitates a thorough investigation of conditions prevailing in the neighborhood.

Methods of Isolating

The system of foundation isolation by means of a space of a few inches all round the block is good so long as it is left at that. It is, however, a common practice to fill this space up with sand or sawdust, and while the effect is satisfactory for a time it is not permanently so, owing to the fact that whatever loose material may be used it will pack together in course of time and will then be of little value as an insulator. If it is imperative that the space should be filled in, the only safe course is to employ one or other of the specially designed insulating materials dealt with later. The all-important part of the foundation so far as isolation is concerned is, of course, the base, and in the past many methods of a comparatively crude and unsatisfactory nature have been tried. Among these may be mentioned layers of timber, sheet lead, rawhide soaked in oil, ordinary roofing felt, loose felt or hair in shallow trays, sand, sawdust, granulated cork and asphalt. These have been used alone and sometimes in combination with one another, and in numerous simple cases there is no doubt with a certain measure of success. They cannot, however, be regarded as solutions to the problem of isolation in bad cases or where the plant is of any size. Their chief fault lies in the fact that they are either insufficiently elastic, as in the case of timber, or that they take a permanent set and eventually become compressed to such an extent that their elasticity is very nearly if not entirely lost.

Rubber

To be of real service an isolating material must be capable of responding to every vibration, and so elastic that after each compression it will return to its original thickness without taking a permanent set. It must be able to retain this quality for years, and must in addition be damp proof for certain situations and able to resist the attacks of insects and rats. One of the first materials to be applied systematically to this purpose was rubber, and there are at present several firms specializing in that direction. The objectionable features of rubber are firstly, its expense, and, secondly, its perishable nature. The former difficulty applies only where a sheet of considerable area and thickness is used; an uncommon practice for that reason. A small machine may be economically isolated in this manner, but, although there are instances of the use of a thick sheet of the same area as that of the foundation, rubber is now seldom applied to large machinery in any form but that of stools or pads.

An example of a special rubber sheet manufactured by a German firm recently came before the writer's notice. A minimum thickness of from about $\frac{1}{8}$ in. is employed, this being suitable for machinery weighing up to three tons. For heavier machinery or where vibration is particularly bad a thicker sheet is used. It is placed either under the foundation, bedplate or footings, and it is important that both the upper and lower surfaces bearing upon it should be very smooth so as to secure an even pressure all over the sheet and the necessary "suction" or adhesion. It would seem that the usefulness of such a system is restricted to comparatively heavy machinery, and the manufacturers do not advise it for light work.

The best known system employing rubber stools is that of M. Prache, a French engineer, who has closely investigated the problems of engine vibration. Under this system the machine is erected on a separate concrete bed varying in thickness with the weight to be carried. This bed, which is entirely free from the floor, rests upon a number of rubber stools, which in turn rest upon the foundation proper. Each stool is carried in a peculiar type of jack, the operation of which compresses the rubber and thus allows it to be withdrawn for inspection or renewal. To give access to the stools a trench is provided all round the foundation. The system has been applied to numerous classes of machinery, and has been very successful when used in connection with large printing presses, the vibration of which is always considerable. Turbo-generating units have also been isolated in this way, and in the case of a 2000-kw. set the subsidiary foundation consisted of a slab of reinforced concrete 2 ft. thick which rested on a series of rubber blocks 4 in. in diameter and 3 in. in height when under compression.

Felt

Felt of the ordinary type used for weather-proofing is of little or no practical use for isolating purposes. It has often been employed, and has been frequently recommended, but experience has shown that while at first it may give satisfaction it will in time take a permanent set and become compressed to such an extent that it loses practically all elasticity. A much better article than this is required for effective and permanent isolation, particularly of heavy machinery, such, for instance, as the "Mascolite" foundation felt manufactured by Mitchells, Ashworth, Stansfield & Co., Ltd., of London Eng. The system of dealing with vibration advocated by this firm is one of the most comprehensive and effective. The felts are specially manufactured in three grades, the first of which is a plain proofed felt ranging in thickness from $\frac{1}{8}$ to 1 in. This is only used on comparatively light work or where there is not much vibration. In the second type, layers of the same felt are alternated with thin layers of cork, the whole being compressed tightly. It ranges in thickness from $\frac{1}{4}$ up to $1\frac{1}{4}$ in. or more, and finds its chief use for engine foundations. The third type employs a thin layer of vulcanized rubber between layers of felt or of felt and cork. The rubber is usually $\frac{3}{32}$ in. thick and the complete pad about 1 in., but these dimensions can be varied.

A very essential point with all isolating substances is that they should be thoroughly waterproof, and these felts are specially treated to that end. They are also immune from the depredations of insects and rats. Iso-

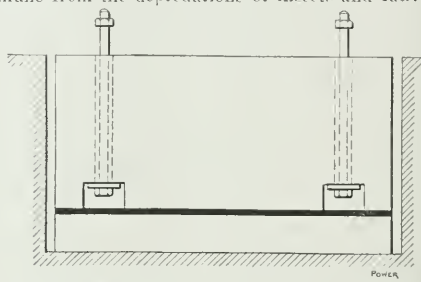


Fig. 1. Method of Isolating Foundation

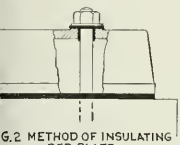
lation of this class may be applied in two ways. It may be placed underneath the main body of the foundation resting on a small subsidiary block, as in Fig. 1, or it may be inserted between the engine bedplate and the top of the foundation, Fig. 2. In the former case there is no difficulty with the holding-down bolts, but in the latter it is necessary to isolate them by bushes where they pass through the bedplate and also to place vibration-absorbing washers of felt under the nuts. If these precautions are not taken, the vibration of the bedplate will travel to the foundation block through the bolts, and the isolation under the bedplate will be of little avail. As regards the important question of permanent set under load and consequent loss of elasticity, some independent tests taken on felt of this manufacture showed the following mean results for the three classes:

	Proofed Felt	Proofed Felt and 3 Layers of Rubber	Proofed Felt and 3 Layers of Cork
Original thickness, in.	0.5	0.96	1.02
Depression in in. at 20,000 lb. per sq.ft.	0.041	0.021	0.047
Depression in in. at 160,000 lb. per sq.ft.	0.249	0.120	0.329
Depression in in. at 300,000 lb. per sq.ft.	0.299	0.205	0.458
Set after 24 hr. release from maximum pressure	0.10	0.03	0.16

Cork

Cork, if correctly applied, is a good isolating medium and has been much used in the form of plates which, of course, have to be built up. There are three methods of doing this, namely, the binding together of small pieces of scrap cork by means of a suitable cohesive substance and pressure; a similar treatment which, however, dispenses with the foreign binding material and relies solely upon pressure and the natural oils in the cork; and the most modern method in which plates are constructed

mmetrically arranged strips of treated cork bound together in a light iron frame. As regards the first, it has been said, and probably with a good deal of truth, that the binding substance employed fills up the pores of the cork, which give it its high elasticity, and, therefore, destroys resiliency. Further, disintegration is always to be feared, and as this would result in partial or total settlement of the foundation the objection is a serious one. The second method is free from the first and perhaps essential disadvantage, but disintegration is to be equally if not more feared, and, therefore, there appears to be little to choose between the two. The third system is the best and most reliable arrangement, but it is, of course, more expensive. The manner of construction is shown in Fig. 3, from which it may be seen that the strips are arranged in squares formed by an external



G.2 METHOD OF INSULATING BED PLATE

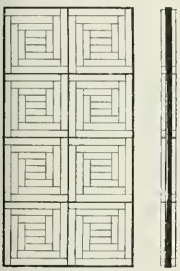


FIG. 3 CONSTRUCTION OF CORK INSULATING PLATE

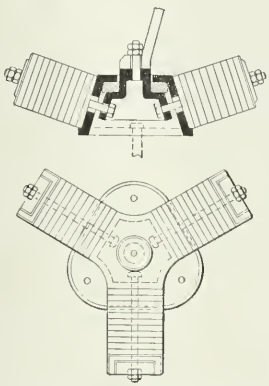


FIG. 4 METHOD OF ISOLATION BY MEANS OF ELASTIC BUFFERS

POWER

ght iron framework and internal longitudinal and teral struts. The cork used is impregnated in a peliar manner in order to increase elasticity and minimize decay, and the plates are specially built to suit the nape of the foundation with minimum and maximum nicknesses of ⅛ and 4¾ in., respectively.

A series of compression tests made on these plates ave average results as follows:

iginal thickness, in.	0.72
ickness in in. under load of 350 lb. per sq.in.	0.50
ickness 30 min. after load was removed, in	0.675
ickness in in. under load of 2500 lb. per sq.in.	0.394
ickness 30 min. after load was removed, in.	0.508

Elastic Buffers and Springs

A novel and, it is stated, effective method of isolation employed by the British Anti-Vibration & Noise Co., td., of Glasgow. The principle is illustrated in Fig. but in practice the arrangement is somewhat different. the diagram one of the feet or part of the bedplate the machine is rigidly connected by a stud to the inrnal floating part of the device. This latter part is pported in the manner shown on three tension memrs, of which the tension can be regulated by the nuts as to equal exactly the weight of the machine. By eans of the plates at the outer ends of the rods the resses in the latter are transferred to the buffers which e built up of a number of elastic plates in layers, and from these to the rigid part of the device which is fixed to the floor by holding-down bolts. There is a further elastic buffer placed between the floating and the rigid parts at the top of the former, as shown, and the function of this is to take up any effect which may tend to raise the machine. The design of this apparatus allows it to absorb both horizontal and vertical vibrations, and also combinations of the two or elliptical vibration. Although it would appear that the stability of a machine might be affected by mounting on such devices it has been found in practice that such is not the case. If the tension of the elastic buffers is properly adjusted there is no perceptible movement and stability is not impaired. A very large variety of machines have been mounted upon isolators built on this principle, which has also been applied in suitable form to the isolation of shafting brackets and alternating-current transformers.

Springs in one form or another have been advocated for isolation purposes, and there is no doubt that for certain classes of machinery, notably electric motors, the proposition is feasible. It is, however, usually a difficult matter to arrive at the correct proportions, and this generally involves a more or less lengthy process of trial and error. Springs of almost every type have been employed for this purpose, including C-springs of various forms, helical springs and coach springs. The latter are preferable as being less sensitive on account of the friction between the leaves of which they are built. This friction damps the oscillation and provides a much more stable arrangement than is possible with any helical spring. The best method of construction is to mount the motor on a frame of stout timbers, to the sides of which two or four coach or bow springs are attached by means of bolts or stirrups. The centers of the springs are fixed to the floor in any suitable way.

❖

Power Progress Display at 1915 Exposition

A feature of the display in the department of machinery exhibits at the Panama-Pacific International Exposition, to be held in San Francisco in 1915, will be the presentation of the successful methods of power development which have been evolved in recent years.

The exhibit is to be a contemporaneous one and not of a historical character; and the evolution of the steam engine, which was the work of the last century, will play only a very small part. The increasing demands for power and the rising cost of fuel have led to the development of types of power producers in which a greater percentage of the latent heat energy in the fuel may be transformed into mechanical power. These developments first proceeded along the lines of devising types of apparatus for utilizing steam in a more economical manner.

Since then the steam turbine, the internal-combustion engine, the Diesel engine and the Humphrey gas pump have been developed, in some cases to great perfection. The abovementioned power machines will constitute the main part of the exhibit.

❖

The largest water-power permit ever issued by the Department of Agriculture was signed, July 16, by Secretary Houston, granting rights to the Pacific Light & Power Co., of Los Angeles, Calif., to operate power plants in the Sierra National Forest. The company will carry electric power 240 miles to Los Angeles at 150,000 volts. The permit allows twelve years for construction. Four power houses, two reservoirs and 25 miles of cement-lined tunnels will be built. Part of the power will be used for pumping water for irrigation in the upper San Joaquin Valley. The electric current will be carried over a double steel-tower line on aluminum cables.—"New York Times."

Flywheel Wreck

A 10x12 center-crank Atlas automatic engine in the plant of the Standard Box & Lumber Co. wrecked itself recently. The engine was driving two small generators which were used for lighting the plant, one belt from each of the flywheels. The automatic governor failed, allowing the engine to run away. The engineer was just outside the engine-room door and heard the exhaust increase. He started to go in, but saw the danger and ran to the boiler room to shut off the steam, but was too late. As the engine gained speed both belts left the wheels, bending one of the armature shafts and wrecking the pulley on the other one. Both the engine flywheels burst. Pieces going through the roof struck a box-car standing 400 ft. away on a side track tearing the corner off the roof and finally landed in a vacant lot. Smaller pieces struck one of the main engines and carried away part of the oil cups. One large piece went through the end of the mill, tearing a large hole and lit in the river, barely missing a man who was working on the log boom. Another piece went through a 1-in. partition, striking the engineer's tool chest, and carried away the top and both ends, then went through the side of the mill.

The switchboard was completely demolished by flying junk. No one was injured.

❖

Western Plants Affected by Dry Weather

That the water supply of Lake Tahoe will be insufficient for power purposes this year is the statement made by engineers in the employ of the Truckee River General Electric Co. after making examinations, surveys and collecting data and statistics on the present supply of water in the lake. Plans are being laid to meet the emergency, but it is conceded that the outlook is very gloomy.—"Engineering Record."

❖

Kelvin Window Dedicated

The Kelvin window in Westminster Abbey, which has been purchased by the members of British and United States engineering societies, is now complete, and the ceremony of dedication took place July 15. The window adds one more to the group erected to the memory of great engineers.

The design for the window has been prepared by J. N. Comper, who was also entrusted with the manufacture of the glass. The sum subscribed amounted to over $8000. The inscription on the window reads: "In memory of Baron Kelvin of Largs, Engineer, Natural Philosopher. B. 1824. D. 1907."

❖

To Fix Power-Plant Valuations

On July 25, a Washington dispatch states, city attorneys and city engineers from 22 municipalities in Yakima, Benton, Franklin and Walla Walla counties, Washington, will meet in North Yakima, to begin preparations for the hearings before the state public service commission to fix the valuation of the electric-power properties of the Pacific Power & Light Co.

The total valuation, between $10,000,000 and $15,000,000, will be used as the basis for rates for current which the public service commission will fix for each community.

Among the cities represented will be North Yakima, Walla Walla, Waitsburg, Dayton, Pasco, Kennewick, Richland, Hanford, White Bluffs, Prosser, Kiona, Benton, Grandview, Mabton, Sunnyside, Granger, Toppenish, Zillah and Yakima City.

The hearing was decided upon by the public service commission last winter in response to complaints from White Bluffs, Pasco, North Yakima and other cities as to rates charged by the company. For the last two months state commission engineers have been working in the field and in the headquarters office of the company in Portland, preparing data on which will be based the finding as to aggregate value.

At that hearing the state, the power company and each municipality will be represented by counsel.

"The method which will be used in determining the value of the property will be far different from that of fixing the value of any property for an assessment or for a sale or mortgage," said G. O. Shumate, city attorney of North Yakima, who issued the call for the meeting of the municipal attorneys and engineers here.

"For an assessment or a mortgage the earning power of a property is secured first and the valuation figured from that. In this case the purpose of the valuation is to fix an income rate which will be equitable to both company and consumer. The approximate method will be to figure the reproduction cost of the construction minus a deterioration charge and to appraise real estate at a market value."

❖

SOCIETY NOTES

The annual convention of the Illuminating Engineering Society in Pittsburgh, Sept. 22 to 26, is particularly fitting as the city will be celebrating the 125th anniversary of Allegheny County. The visitors will see Pittsburgh in its holiday attire and witness many special illuminating features. The papers committee has secured a number of papers the subjects and authors of which are sufficient to attract favorable attention.

The first International Exposition of Safety and Sanitation held in America will take place in New York City, Dec. 11 to 20, under the auspices of the American Museum of Safety and health in every branch of American industrial life, manufacturing, trade, transportation on land and sea, business, engineering, in all of their subdivisions will be represented at this exposition. There will be no limit to the scope of the exposition; it will embrace everything devoted to safety, health, sanitation, accident prevention, welfare and the advancement of the science of industry. By a special act of Congress, exhibits from foreign countries are to be admitted free of duty. European employers have cut their accident and death rate in half by a persistent campaign for safety. There are 21 museums of safety in Europe, all of which will contribute to the American Exposition.

The American Boiler Manufacturers Association will hold its twenty-fifth annual convention in Cleveland, Ohio, Sept. 1 to 4, with headquarters at the Hollenden Hotel. This convention will prove of special interest to boiler and tank manufacturers and steel-plate users in consequence of the proposed adoption of the standard and uniform boiler specifications, also from the fact that this celebrates the silver anniversary of the Association. As Cleveland is centrally located, a large attendance is expected from Canadian and United States manufacturers and allied interests. The local committee has provided an excellent program of entertainment for the visiting ladies, and an excursion on the lake, Sept. 3, for the members and guests. The convention will conclude with a banquet Thursday evening, Sept. 4. All of the manufacturers and users of steel plate are invited to attend the convention. Reservations for rooms should be made at once.

PERSONALS

Frank Morrison has been appointed chief engineer of the power station of the Union Traction Co., Coffeyville, Kan., to succeed O. E. Polk.

C. S. De Witt, formerly superintendent of the National Machine Works, has taken the position of chief engineer of the Bartlett Bldg., Atlantic City, N. J.

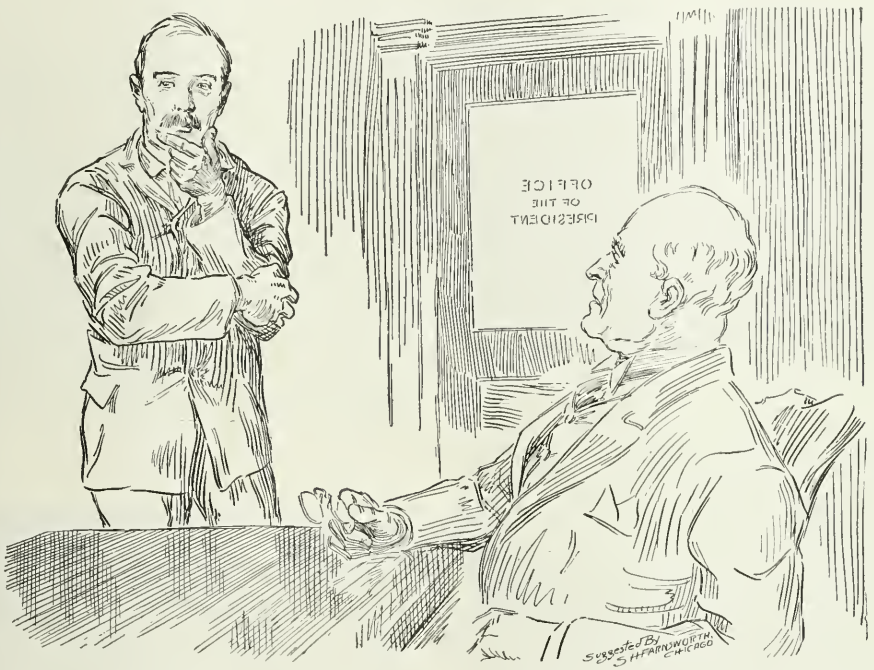
Colonel George W. Goethals, chairman of the Isthmian Canal Commission and chief engineer of the Panama Canal, has consented to accept the honorary presidency of the International Engineering Congress and will preside over the general sessions to be held in San Francisco Sept. 20-25, 1915.

F. Z. Nedden, of London, England, has been appointed engineer in charge of the centrifugal pump department of the Goulds Manufacturing Co., Seneca Falls, N. Y. Mr. Nedden was educated at the University of Berlin in Germany. For seven years he was employed in the shops of the Berliner Maschinenbau A. G. vormals L. Schwartzkopff in Berlin and Wildau. From 1906 to 1908, Mr. Nedden was assistant professor at the Technical University at Aix-la-Chapelle. In 1908, after a trip through Europe to investigate the manufacture and application of high-lift turbine pumps he entered the machine and pump factory of Weise & Monski, Halle, Germany, where he developed a series of high-lift turbine pumps. In 1910 he was transferred to the firm's London headquarters, where he had charge of its English and Colonial business. Mr. Nedden is the author of several textbooks in German, some of which have been translated into English. He is a member of the Verein Deutsches Ingenieure and other technical and engineering societies.

POWER

Vol. 38 NEW YORK, AUGUST 19, 1913 No. 8

An Anxious Moment



"You have been with us quite a while, George!"

"Nearly fifteen years, sir"—a moment's silence.

"Ahem, we have decided to tear out our present plant, with all its antiquated equipment, which, although all right in its day, has outlived its usefulness. We will install a first-class, uptodate plant, water-tube boilers, mechanical stokers, centrifugal pumps, turbo-generators, and use motors to drive the machines direct.

"Could you handle that type of plant, George?"

What would your answer have to be?

If George has used his spare time for the past 20 years improving his mind and training himself for the change that will come to all of us sooner or later, the anxiety will not last long.

But, if he has just drifted along with the times, taking things as they come, just attending to his duties and allowing his interest in engineering to end with the day's work, he will take second place or join the ever-increasing crowd of ex-engineers.

How Boiler Plate Is Made

By Charles H. Bromley

SYNOPSIS—The reader virtually takes a trip through the mills and sees the manufacturing process from the stock pile to the finished product. The spinning of flanged, bumped boiler heads is described. The imperfections which sometimes exist in the manufacture of the plate and which affect the material for boiler purposes are illustrated and explained.

The Stock Pile

The manufacture of steel boiler plate really begins at the stock piles, of which there are usually two, one consisting of pig iron and the other of melting scrap.

Fig. 1. Charging Boxes with Scrap on Way to Melting Furnace

Some of the scrap is comparatively free from phosphorous, but the remainder, consisting of steel rails and the usual kinds of scrap purchasable in the market, contains more phosphorus than is permitted in good boiler plate.

The pig iron also usually contains still more phosphorus than the scrap.

This material, however, may be dephosphorized by being melted in a furnace containing a charge of limestone, which when the whole mass is melted absorbs the excess phosphorus.

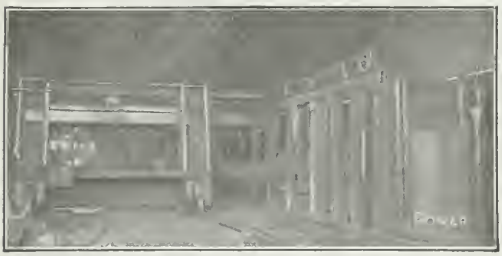


Fig. 2. Crane for Charging Furnace with Scrap

Large gantry cranes carrying magnets load the pig iron and scrap into the charging boxes. Fig. 1 shows a number of these boxes loaded and on their way to the melting furnaces. Holes are drilled in the bottoms of the boxes to prevent an accumulation of water therein which if dumped into the furnace might cause a serious explosion.

Charging the Melting Furnace

When the train load of boxes is left in front of the melting furnaces the horizontal arm of a charging crane slips into a slot in the end of the box and lifts the latter into the furnace. Fig. 2 shows the crane holding the box which is shown at the right.

The melting furnaces, holding 50 tons of metal, are heated with gas furnished by gas producers; the temperature maintained is about 3000 deg. F., at which the steel boils. The gas-flame current playing over the top of the metal is reversible. A "heat" is poured every twelve hours.

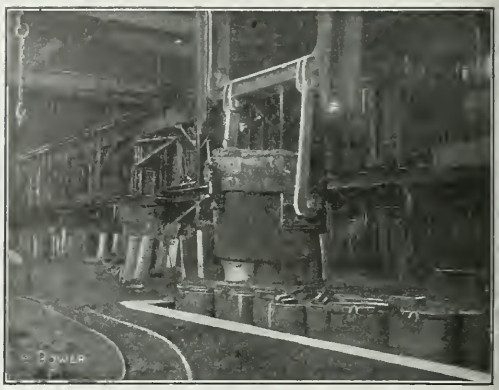


Fig. 3. Pouring Steel into Ingot Molds

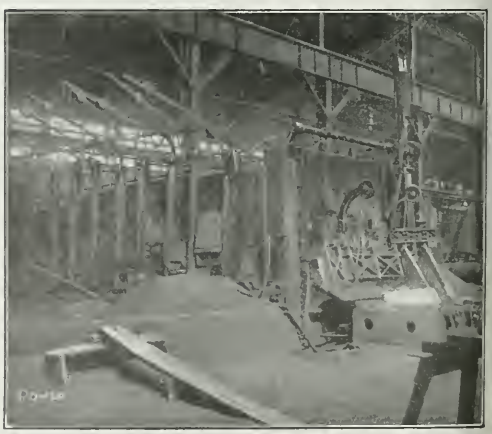


Fig. 4. Bloom after Passing through Continuous Furnace

Pouring the Molten Steel

The pouring side of the melting furnaces is shown in Fig. 3. Here a heat is being poured into the ingot molds from the bottom of a ladle which holds the entire contents of the furnace. This method of pouring is known as "bottom" pouring because the molten steel is poured into a form having passages leading to the bottom of each mold, the metal rising to the top of the molds as the pouring is continued.

Sometimes the steel does not contain the specified amount of carbon and this shortage is not discovered until the metal is being poured into the ladle. To make up this shortage several bags, like flour sacks, are kept full of a high grade of No. 3 buckwheat coal. These bags are thrown into the molten steel as it flows to the ladle. The coal is immediately consumed and some of its carbon content added to the steel.

Heating the Ingots for Rolling

The ingots vary in weight from 500 to 25,000 lb. Marine steel plate being heavy, it is rolled from the larger ingots. After the steel in the molds has solidified and while the ingots are quite hot they are carried by cranes to the continuous furnaces. Here the ingots are put in at one end and carried through to the other, being white hot when they are dropped out at the terminal end, as shown in Fig. 4, which illustrates a heated ingot just dropped from the furnace.

Rolling the Ingots into Plates

In blooming mills the ingots are rolled into blooms and these are cut into billets which are carried by high-speed electric cranes and dropped on the stationary feeder rolls of the plate mill, Fig. 5. The illustration shows a "three-high" mill, so called because it has three reducing rolls. The second set of feeder rolls shown at the end of the stationary feeder rolls may be tipped so as to come in line with the upper or lower reducing rolls.

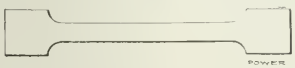


Fig. 6. Form of a Steel Test-Piece

In a mill so made the hot metal passes through the mill between the middle roll and the upper roll when going one way, and when returning is passed between the lower roll and the middle roll, being made thinner each time it goes through the mill. The work is kept in rapid motion until the plate is reduced to the desired thickness, which is indicated by a gage used by the attendant. The long levers hung by chains from the top of the rolls are used to turn the billet so that it will enter the rolls properly.

Oxidization occurs on the surface of the ingot due to the cooling action, and if the scale were not removed it would be rolled into the metal producing a defective plate. Therefore a steam pipe is provided with nozzles pointing downward to deliver steam jets for blowing the loose scale off the ingot. Sometimes the scale adheres so firmly that the steam jets are not strong enough to remove it. At such times common salt is thrown over the surface of the plate. The salt causes violent explosions as the plate passes through the rolls. The scale is thus loosened and then is blown from the plate by the steam jets.

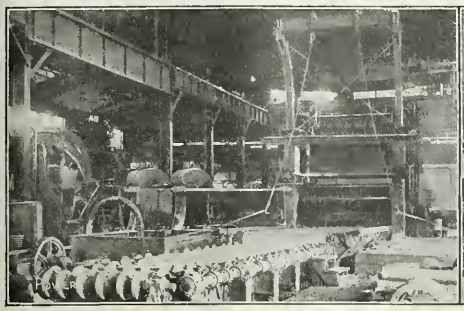


Fig. 5. Rolling Mill

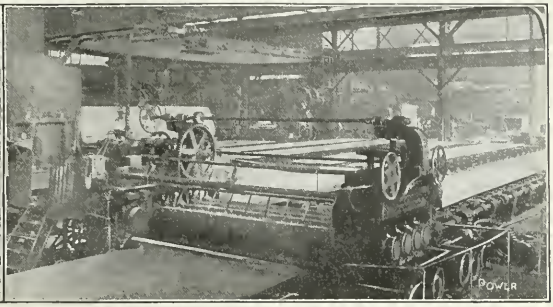


Fig. 7. Straightening Rolls

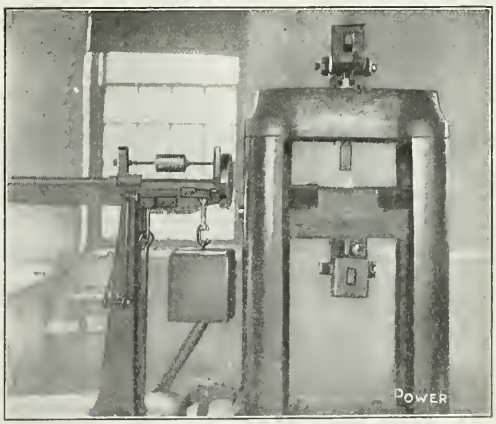


Fig. 8. Machine for Testing Elasticity and Tensile Strength of Plate

It will be understood that the space between the reducing rolls is adjusted each time the hot metal passes through the mill.

From its more frequent use the middle roll wears more rapidly than the upper and lower rolls. This middle roll is taken out and trued up in a large roll lathe, and the top and bottom rolls, which are larger, are trued

up in position by disconnecting the main shaft and substituting motor drive through gears to obtain a slow speed, a tool rest being provided in front of the roll. Each mill is driven by its own engine, which usually is of 3000 or 4000 horsepower.

As the plate is more or less wavy as it comes from the mill, it is continued, while hot, to the straightening

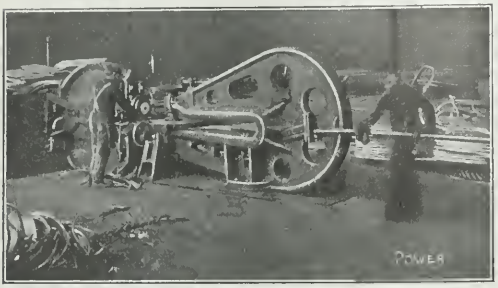


Fig. 9. Cutting Plate for Boiler Heads

rolls, Fig. 7. After being straightened the plate is carried at right angles to the rolls and is later tipped up so that both sides may be inspected for defects. The white object in the middle distance, Fig. 7, is a plate, tipped for inspection. The plate is next trimmed and cut into sheets.

Testing the Physical Properties of the Plate

The finished plate is next given a number and series mark and a "coupon" piece cut from it which is also given the same number and series mark. The "coupons" are of a unit size and milled out to the shape shown in Fig. 6.

To test for elastic limit (permanent stretch) and tensile strength, the machine, Fig. 8, is used. After the ends of the test piece have been gripped in jaws, one stationary and the other movable, the piece is pulled until

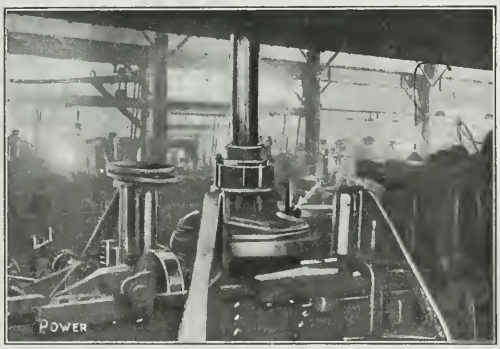


Fig. 10. Spinning Flanges on Boiler-Head Plate

the elastic limit is reached. The number of pounds pull necessary to reach this limit is recorded. Next comes the tensile-strength test. The pull is continued, stretching the piece until it finally breaks, and the pull necessary to produce the break is also recorded. The ductility is determined by the amount of stretch or elongation between two points marked 8 in. apart before pulling. As an additional test for ductility, a piece is subjected to a bending stress by being placed vertically in a hydraulic press and bent double. If the piece breaks or fractures it has not withstood the test.

Spinning Flanges on Plates for Boiler Head

The plate is cut into circular pieces of the required diameter by rotary shears shown in Fig. 9. The pieces are then placed in a furnace which heats the entire plate, after which the plate is placed in the spinning machine, Fig. 10, and the flanges turned down. In the illustration the plate is shown in the machine after the flange has been spun.

To put in a plate the top die is raised, and lowered again after the plate is centered, the vertical rollers moving in toward the plate pushing it central on the dies. The machine is then started and as the plate revolves, the wheel, indicated by the arrow, is moved toward the center of the plate and at the same time is moved down-

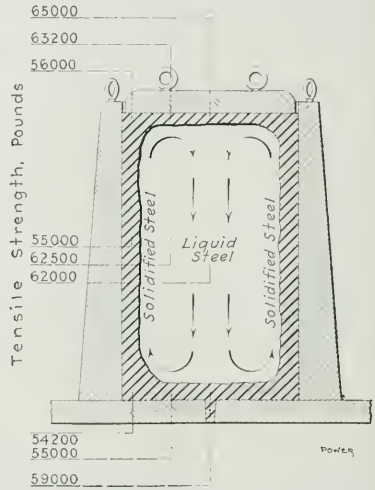


Fig. 11. How Cooling of the Ingot Affects the Tensile Strength

ward, describing an arc. This process causes the plate to be pressed down over the die without kinking, thus securing a uniform curvature. The head is again heated locally preparatory to being fitted with a manhole flange and cover.

Imperfections in the Ingots

As the steel cools in the molds a steadily thickening wall of solidified metal forms at the sides of the mold. A current of gas bubbles rises next to the solidified wall while a downward current is created in the center of the liquid metal. This thoroughly mixes the carbon and other hardening elements in the liquid portion, but much of these elements are expelled from the solidifying wall, consequently the liquid portion continually gains in these elements. This action is shown in Fig. 11.

Eventually the metal reaches a temperature where it becomes plastic, preventing gas formation or currents. The segregation of the hardening elements ceases and the metal inclosed by the zone of gas bubbles solidifies in a mass of comparatively uniform character.

The test pieces, previously mentioned, are usually cut

from shearings from the edges of the plates and therefore represent the metal which was part of the solified wall in the cooling ingot, and which is much softer than the metal in the center of the plate.

For carrying high pressures, a plate of high tensile strength is usually specified, and due to the conditions of manufacture, this often results in the use of material so hard in its interior parts as to suffer distress in working to shape. This reduces the actual factor of safety allowed in the finished boiler. To prevent trouble arising from the above conditions, some authorities recommend that ductility be introduced as a factor in conjunction with tensile strength to determine the allowable working stresses so that a steel of lower tensile may be used, if it shows a corresponding increase in ductility.

The writer expresses thanks to Charles L. Huston, vice-president of the Lukens Iron & Steel Co., Coatesville, Penn., for his kindness in showing him through the works and enabling him to obtain the information contained in the article.

Adaptation of Boiler to Available Coal*

By Henry Kreisinger and Walter T. Ray

SYNOPSIS—Description and summary of tests showing the economic effect of changing the baffle arrangement in a horizontal water-tube boiler for use with coals of different characteristics. The tests clearly show the advantage of giving the gases plenty of room in which to burn.

The coals of the New River and Pocahontas fields differ considerably from those of Virginia and still more from those to the southwest, in that the first-mentioned contain about 20 per cent. of volatile matter and the remainder 30 per cent. and more. In addition, the oxygen content is low, so that the volatile combustibles run high. Coals high in volatile matter and low in oxygen need plenty of room in which to burn and the high rate of

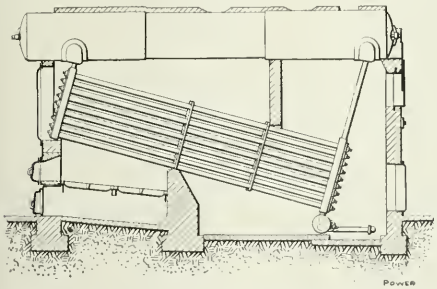


Fig. 1. The Test Boiler with Vertical Baffles

combustion obtainable on a comparatively small grate surface renders such coals desirable when working boiler investments at a high rate. That is to say, the fixed carbon residuums of all coals burn on grates at about the same rates under the same conditions of draft, etc., and any burning of volatile matter in the space above and beyond the fuel bed means so much additional capacity or increased rate of steam production.

Object of Tests

The object of the tests herein described was to determine whether by baffling the boiler horizontally, thereby obtaining a larger combustion space in the furnace, high-volatile coal could be burned with good results and, at the same time, to determine whether, with the horizontal baffle, Pocahontas coal could be burned as economically as with the standard vertical baffle.

Two kinds of coal were used in the tests, Pocahontas and Clinchfield. The Pocahontas coal was from Mercer

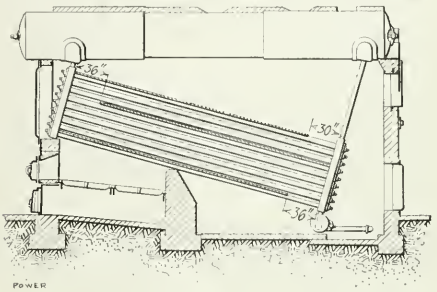


Fig. 2. Boiler Baffled Horizontally for Second Series

County, W. Va., and the Clinchfield coal was from Dante, Va. All coal used in the tests was straight run-of-mine.

Scope of Tests

The tests were made in three series: The first consisted of seven tests, with the boiler baffled vertically as installed by the maker. The location of the baffles and the principal features of the boiler are shown in Fig. 1.

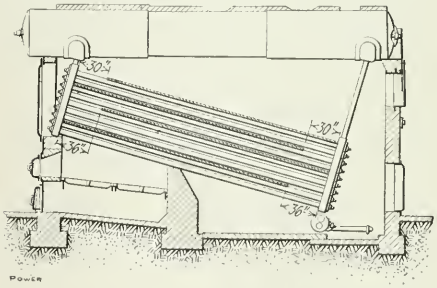


Fig. 3. Boiler Baffled for Three Passes among Tubes

Four tests of this series were made with Clinchfield coal and three with Pocahontas.

The second series consisted of seven tests with the same boiler baffled horizontally in such a way that the space

*Abstract of paper presented to Western Society of Engineers, Chicago, June 2.

beyond the bridge-wall was used as a combustion chamber, the burning gases passing lengthwise, first under the boiler and then twice among the tubes and out through the breeching. The heating surface of the drums was not used with this baffling. The arrangement of the baffles and the path of the gases are shown in Fig. 2. Three of these tests were made with Pocahontas coal and four with Clinchfield coal.

The third series, consisting of five tests, was made with the same boiler baffled horizontally in such a way that the gases passed lengthwise under the boiler as in the second series, then three times among the tubes and finally under the steam drums and out through the breeching. The arrangement of the baffles and the path of gases are shown in Fig. 3. Three tests of this series were made with Clinchfield coal, and two with Pocahontas.

Method of Conducting the Tests

All 19 tests were run under the actual operating conditions of the plant. Usually the tests were begun in the morning when the work at the mill was started and were run through the day (with a 30-min. stop at noon) until 6 o'clock in the evening, when the mill was shut down. At noon the main engine was stopped and there was no demand for steam for about 30 min. During this period the chimney damper was closed. During the tests all coal burned was carefully weighed in a wheelbarrow and the water used in the boiler was measured in a special tank and fed with an injector into the test boiler. The temperature of the feed water was determined in the measuring tank, inasmuch as the water in the suction tank was always hotter on account of the overflow from the injector. The temperature of the outside and inside air, as well as that of the escaping flue gases, was determined. In most of the tests samples of the flue gases were collected and analyzed in an Orsat apparatus. Records of steam pressure and drafts were also kept. These records made it possible to compute the results accurately and express them in pounds of water evaporated per pound of coal. During each test the blowoff piping was disconnected and the amount of leakage measured.

In starting and stopping the tests, a modification of the "alternate method" was used. The fire was cleaned either early in the evening or at about 4 o'clock in the morning; it was then banked and left in that condition until about 5:30 o'clock. At that time the banked coal was spread over the grate and more fresh coal was fired two or three times. Before starting, the firing was suspended for 15 or 20 min. so as to have a thin uniform layer of hot coke on the grate.

When starting the tests the fuel bed was carefully leveled and its thickness measured by dipping into it the prongs of the rake and noticing to what depth the prongs sank into the fuel. The thickness of the fuel bed when the test was started was usually about 2 in. or even less. The object of starting with a thin fire was to reduce the error in estimating the thickness of the bed. The height of water in the gage-glass and in the suction tank was measured and recorded.

When closing the tests the fire was burned down to the same thickness as at the start. The thickness in this case was measured above the layer of clinker and ash. Also at this time the water in the gage-glass was brought as nearly as practicable to the same height as when the test was started. In case the fuel bed was burned down to the right thickness before the water in the gage could be brought to the same level as it was at the start, the test was closed and corrections were made for the difference in water level.

The first was not cleaned before closing the test for two reasons, namely: In the regular operation of the plant the fires were never cleaned before the end of the day's run, and it was desirable to make the tests under as nearly regular operating conditions as possible. It would have been difficult to keep up the steam pressure if the fire had been cleaned while the mill engine was running.

Soon after starting each test the ashpit was cleaned and the fire was run all day without removing any clinker from the furnace or any ashes from the ashpit. About half an hour before closing the test the ash from the ashpit was removed, weighed and charged to the test. About 10 min. after closing the test, the fire was cleaned and all the refuse pulled out from the furnace was weighed and also charged to the test. Ordinarily, when no test was run, the fire was not cleaned until about 4 o'clock in the morning.

As the coal used in the tests was weighed, a shovelful was taken from each wheelbarrow for a sample. The sample thus collected was carefully quartered and sent to a chemical laboratory for analysis. The average of these analyses for each series of tests is given in the table of results.

TABLE I CHIEF DIMENSIONS OF TEST BOILER

Type of boiler	horizontal water tube
Capacity as rated by builders, boiler horsepower	250
Number of horizontal rows of tubes	9
Number of tubes in each horizontal row	14
Total number of tubes in boiler	126
Diameter of tubes, in.	4
Length of tubes, ft.	18
Number of steam drums	2
Length of steam drums, ft	20.3
Diameter of steam drums, in.	36
Water heating surface of tubes, sq.ft.	2381
Approximate water-heating surface of drums, sq.ft.	165
Furnace	
Width of grate, in.	96
Depth of grate, in.	72
Height of bridge-wall, in.	20
Kind of Grate	shaking
Approximate width of air spaces, in.	$\frac{3}{4}$
Approximate percentage of air spaces	30
Total grate area, sq.ft.	48
Stack	
Diameter of steel stack, in.	48
Height of stack, ft.	80
Approximate length of steel breeching, ft.	10
Size of steel breeching, ft.	4x4
Gas Passages	
Length of gas path among boiler tubes with standard three-pass vertical baffling, ft.	13.5
Length of gas path among boiler tubes with two-pass horizontal baffling, ft.	30.0
Length of gas path among boiler tubes with three-pass horizontal baffling, ft.	45.0
Clear cross-section of gas passages of two-pass horizontally baffled boiler	
Over bridge-wall, sq.ft.	8.1
First pass, sq.ft.	14.6
Second pass, sq.ft.	8.7
Clear cross-section of gas passages of three-pass horizontally baffled boiler	
Over bridge-wall, sq.ft.	10.9
First pass, sq.ft.	8.4
Second pass, sq.ft.	5.6
Third pass, sq.ft.	5.6

The boiler used in the tests was one of three similar boilers in the plant and its principal dimensions are given in Table 1. It was set by itself and provided with its own steel stack. The stack was placed outside of the boiler room on a brick foundation and connected with the boiler by a horizontal steel breeching 4x4 ft. in cross-section. The furnace was equipped with a rocking grate.

Summary of Test Data and Results

Table 2 gives the average of all data and the calculated results of the 19 tests. The calculations were made according to the rules given in the Code for Testing Steam Boilers of the American Society of Mechanical Engineers.

TABLE 2. RESULTS OF 19 TESTS

	Standard Original Baffling						Horizontal Two-Pass Baffles						Horizontal Three-Pass Baffles					
Test number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Kind of coal*	Poca-hontas	Poca-hontas	Clinch-field	Clinch-field	Clinch-field	Poca-hontas	Poca-hontas	Poca-hontas	Poca-hontas	Poca-hontas	Clinch-field	Clinch-field	Clinch-field	Poca-hontas	Clinch-field	Clinch-field	Clinch-field	Poca-hontas	Poca-hontas
Date of test	Mar. 5	Mar. 6	Mar. 18	Mar. 19	Mar. 20	Mar. 27	Mar. 22	May 6	May 9	May 14	May 15	May 16	May 17	May 26	Aug. 29	Aug. 30	Sept. 2	Sept. 3	Sept. 4
Duration of test, hours	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Steam pressure by gage, lb.	140	140	140	140	143	145	145	145	145	146	146	140	140	146	142	142	140	145	145
Draft in breeching, in. of water	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Draft in furnace, in. of water	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Temperature of external air, deg. F	42	37	74	68	81	80	56	75	80	78	75	65	72	66	66	66	66	66	66
Temperature of fireroom, deg. F	54	52	80	75	88	85	71	85	92	92	85	75	82	76	94	98	105	104	98
Temperature of steam, deg. F	361	361	361	361	362	363	363	363	363	363	363	363	363	363	362	362	362	363	363
Temperature of feed water, deg. F	79	73	78	78	84	79	84	86	85	98	98	90	92	87	98	98	95	98	98
Temperature of chimney gases, deg. F	584	610	519	547	615	618	666	585	528	541	586	540	538	530	501	501	503	490	486
Coal over 1-in. screen, per cent			55			55	25	15	20	20	35	35	35		47				
Coal through 1-in. screen, per cent																			
Weight of coal fired, lb	5556	13,508	6184	12,325	13,383	14,404	12,962	11,502	12,000	12,600	13,500	14,100	13,950	13,800	11,100	10,140	11,700	11,300	9405
Total ash and refuse, lb	458	710	118	758	987	1039	693	539	744	820	1040	690	1114	873	952		762	858	
Per cent. of clinker in refuse				59	32	44	60	67	65	70	53		57	55	59			46	
Coal consumed per hour, lb	1054	1317	1047	1085	1181	1245	1092	1046	1090	1197	1276	1282	1284	1245	1025	988	1080	1043	985
Total heating surface, sq. ft	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250	2250
Total weight of water fed to boiler, lb	44,159	107,238	48,465	96,458	98,007	115,739	104,469	90,885	104,000	106,373	108,265	117,817	113,802	115,504	93,258	85,236	99,153	101,477	82,042
Factor of evaporation	1.187	1.193	1.180	1.188	1.183	1.177	1.181	1.172	1.169	1.169	1.177	1.177	1.171	1.180	1.168	1.168	1.172	1.167	1.168
Equivalent water fed to boiler, lb	52,414	120,776	57,024	107,475	115,942	136,224	123,378	117,005	121,576	124,350	127,427	138,671	133,603	136,295	108,806	103,059	116,207	118,415	95,815
Equivalent evaporation per hr., lb	10,317	11,783	9767	9553	10,233	11,774	10,385	10,462	11,052	11,222	12,041	12,606	12,279	12,300	10,052	10,054	10,730	10,934	10,001
Horsepower developed	290	341	283	276	297	341	301	308	320	326	349	365	356	356	291	291	311	317	290
Percentage of builders' rated horsepower developed	110	136	113	111	119	136	120	123	128	130	139	140	142	142	116	116	124	127	116
Equivalent evaporation per sq. ft. of heating surface, lb. fired, lb.	4.59	5.24	4.34	4.25	4.55	5.23	4.61	4.57	4.91	4.99	5.35	5.60	5.46	5.47	4.63	4.63	4.78	4.86	4.45
Equivalent evaporation per lb. of coal as fired, lb.	9.78	7.94	9.32	8.72	8.66	9.45	9.15	10.15	10.13	9.87	9.44	9.83	9.57	9.87	9.86	9.96	9.61	10.47	10.17
Average thickness of fuel bed, in	8	8	6	6	6	8	7	7	7	8	6	6	6	6	6	6	6	6	6
Average per cent. of CO_2 in flue gases	7.3	8.8	7.2	6.54		7.7	8.89	7.3	7.2	7.5	7.76		9.3	10.8	9.0	9.2			
Average per cent. of O in flue gases						11.2	10.63	12.5	11.5	11.7	11.26		9.3						
Average per cent. of CO in flue gases						0.45	0.16	0.15	0.16	0.15									
Maximum per cent. of CO in flue gases						2.2		0.4	0.6	0.4									
Calorimeter temperature, deg. F						525		525	528	528									
Air used per lb. of carbon, lb.						30.3		27.0	32.0	33.5	32.4	29.5		26.2	26.7				

AVERAGE COMPOSITION OF COALS

	Moisture Per Cent.	Ash Per Cent.	Vol. Per Cent.	Fixed Carbon Per Cent.	B.t.u.	Moisture Per Cent.	Ash Per Cent.	Vol. Per Cent.	Fixed Carbon Per Cent.	B.t.u.	Moisture Per Cent.	Ash Per Cent.	Vol. Per Cent.	Fixed Carbon Per Cent.	B.t.u.
Pocahontas	0.62	4.9	17.12	77.36	14,828	.....	4.72	.....	.....	15,050	1.12	5.5	15.76	77.62	14,731
Clinchfield	0.77	7.9	32.00	59.33	14,122	.....	10.26	.....	.....	13,801	0.98	9.85	29.00	60.14	13,756

* Run-of-mine.

Method of Firing

In all the tests a modification of the spreading method of firing was used. When firing, the coal was thrown on the thin spots in the fuel bed, omitting the high places. Coal was fired in small quantities at short intervals. By this method it was possible to keep the fuel bed uniformly thick all over the grate without the use of a rake or other fire tool. This method of firing was particularly successful with the Clinchfield coal. Most of the tests with the Clinchfield coal were run without using the rake at all during the day.

Behavior of the Coals on the Grate

The Pocahontas coal caked considerably. Perhaps a large part of this caking property was due to the fact that the coal contained a high percentage of slack. The freshly fired coal fused and formed a crust on the surface of the fuel bed. This crust cracked in some places, and through the cracks air passed into the furnace. When firing, effort was made to put the coal into the cracks of the fuel bed. By this method it was possible to keep the bed in good condition from one to three hours without using the rake. When the fuel bed became too uneven, the crust was broken and the fuel was leveled with a rake. When the coal contained more lumps, there was less trouble from the formation of crust.

The Pocahontas coal did not clinker. At the end of a day's run the refuse pulled out of the furnace consisted of large pieces of free ashes. Smaller pieces of ashes were removed from the fuel bed by rocking the grate two or three times a day.

Part of the Clinchfield coal was lumpy and burned freely. Usually it was possible to run the fire through the day without using the rake. The coal caked very little but clinkered rather badly. The clinkers were, no doubt, partly responsible for the low capacity obtained in the first series of tests. When the fire was cleaned after the close of each test, the clinkers were pulled out of the furnace with difficulty. The clinker formed in one large sheet over the entire grate and adhered to the side walls and the bridge-wall. This clinkering property was the main objection the men connected with the operation of the plant had to this grade of Clinchfield coal. The rocking of the grate gave no relief from clinker.

The balance of the Clinchfield coal looked much like the first-mentioned lot and possessed all of its properties except that it did not clinker. In composition, however, it was not as good. There was a considerable quantity of impurities in it which made the ash content 2 or 3 per cent. higher than that of the other, reducing the heat value by the same amount. However, the fact that the coal did not clinker made it much the better of the two grades for this particular plant. By shaking the grate

three or four times a day the fuel bed was kept in good condition. The rake was usually not used at all. After the close of the test when the fire was cleaned, practically no clinker was found on the grate. The refuse consisted of large pieces of loose ash which could be removed with ease.

It should be remembered that during the tests the boiler was run considerably above its rated capacity all the time. During the regular operation, the boilers would not be run above their rated capacity and, perhaps, most of the time they would be operated below it. It is

TABLE 3. SUMMARY OF TEST RESULTS

	Standard Original Baffling		Boiler with Two Horizontal Passes		Boiler with Three Horizontal Passes	
	Pocahontas Coal	Clinchfield Coal	Pocahontas Coal	Clinchfield Coal	Pocahontas Coal	Clinchfield Coal
	Average of four tests	Average of three tests	Average of four tests	Average of three tests	Average of two tests	Average of three tests
Pounds of water evaporated under actual conditioos per lb. of coal as fired	7.95	7.49	8.54	8.18	8 83	8 52
Equivalent evaporation per lb. of coal as fired, lb.	9.42	8.90	9.92	9.61	10 33	9 97
Average hp. developed	320	285	335	357	303*	298*
Maximum hp. developed	341	297	355	365	317	311
B.t.u. per lb. of dry coal	14,828	14,122	15,050	13,801	14,731	13,750
Ash, per cent.	4.9	7.9	4.72	10.26	5.5	9.85
Approximate efficiency of boiler and furnace, per cent.	61.3	60.9	63.6	67 2	67 7	69 9

* Note: On the test with three horizontal passes, higher capacity could have been developed but the feed water was too hot and the injector would not feed it fast enough into the boiler.

high efficiency. In the horizontal three-pass boiler t draft over the fire is considerably reduced; hence, th is less chance of drawing too much air into the furna Therefore, with careless firing, the difference in efficien in favor of the three-pass horizontal baffle is much grea than with careful firing. In other words, the horizonta baffled three-pass boiler is more nearly proof against ca less firing and manipulation.

Conclusions

In Table 3 is given a summary of the results of t tests. The preceding summary of results shows c clusively that much better results can be obtained w Clinchfield coal when the boiler is baffled horizontal There is also a marked improvement in the results favor of the horizontal baffling when Pocahontas coal used as fuel. The horizontal three-pass baffling gives t highest evaporation; the horizontal two-pass baffling gi the highest horsepower developed during tests.

With the two-pass horizontal baffling better evaporati and higher horsepower can be obtained with Clinchfi than with Pocahontas coal and the standard verti baffling.

Discussion

E. A. Fessenden: The percentages of loss to the sta shown in Table 4, which I have compiled to bring c more clearly some points of comparison between the d

TABLE 4. SHOWING POINTS OF COMPARISON BETWEEN DIFFERENT BAFFLE ARRANGEMENTS

Coal	Baffling	Test No.	Draft Pressures Inches of Water: In Breeching	In Furnace	Loss through Boiler	Temperatures Deg. F.: Chimney	Fire Room	Difference	Per Cent. CO_2	Per Cent. Excess Air	Lb. Air per Lb. Combustible (Assuming Chemical Requirement Equals 11 Lb.)	Loss to Stack B.t.u. per Lb. Combustible	Per Cent. Loss to Stack	Efficiency (Over All)	Boiler Efficiency (1—Stack Losses)
Pocahontas	Original Vertical	1	1.00	0 38	0 62	584	54	530	7.3	151	27 6	3640	23 2	64.0	0.8
		2	1 00	0 44	0 56	610	52	558	8 8	109	23.0	3220	20 .5	58.5	0.7
		6	0 88	0 38	0 50	618	85	533	8 89	106	22 7	3030	19 3	61 9	0.7
		7	0 88	0 38	0 50	606	71	535	7 3	151	27 .6	3670	23 .4	62 2	0.7
														Av. =	0.7
	Two-Pass Horizontal	8	0 69	0 31	0 38	485	85	400	7.2	155	28 .1	2790	17 .8	65.9	0.8
		9	0 69	0 31	0 38	522	92	430	7 .5	146	27 1	2890	18.4	65 .6	0.8
		10	0 69	0 31	0 38	541	92	449	8 .2	125	24 .7	2770	17 .7	63 .3	0.7
		14	0 81	0 31	0 50	550	76	474	10 8	69	18 .6	2230	14 .2	63 .3	0.7
														Av. =	0.7
	Three-Pass Horizontal	18	0 75	0 19	0 56	490	104	386						69 .1	
		19	0 81	0 19	0 62	486	98	388						67 .0	
Clinchfield	Original Vertical	3	1 00	0 44	0 56	519	80	439	7 .2	155	28 .1	3060	19 .8	64 .0	0.7
		4	0 88	0 44	0 44	547	75	472	6 .54	178	30 .6	3580	23 .1	59 .8	0.7
		5	0 88	0 38	0 50	615	88	527	7 7	140	26 .4	3470	22 .4	59 .5	0.7
														Av. =	0.7
	Two-Pass Horizontal	11	0 75	0 31	0 44	588	85	503	7 76	137	26 1	3270	21 .1	66 .3	0.8
		12	0 81	0 31	0 50	543	75	468	9 5	93	21 .2	2490	16 .1	69 .1	0.8
		13	0 81	0 31	0 50	533	82	451	9 3	97	21 7	2460	15 9	67 3	0.8
														Av. =	0.8
	Three-Pass Horizontal	15				507	94	413	9 0	104	22 5	2330	15 .1	69 .2	0.8
		16	0 75	0 25	0 50	501	88	403	9 2	100	22 0	2220	14 .4	71 .6	0.8
		17	0 81	0 19	0 62	503	105	398							
														Av =	0 8

reasonable to expect that under these conditions, the efficiency will be even higher than is shown by the tests.

With the present standard baffling of the boilers, the heat lost with the chimney gases is excessive. During the last series of tests, the writers measured with an anemometer the velocity of air entering the ashpits of the test boiler and also of another boiler, the latter equipped with the standard vertical baffles. It was found that with the test boiler the velocity was about 450 ft. per min.; with the other boiler it was about 800 ft. per min., or nearly twice as much, although only about two-thirds as much coal was being burned under the latter. This velocity measurement showed conclusively that entirely too much air was used in the vertically baffled boiler. The area of the ashpit doors of both boilers is the same.

The aim in the preceding paragraph is to show that high draft over the fire is often misused to draw too much air into the furnace and is in such cases detrimental to

ferent baffling arrangements, were estimated by the f lowing approximate method:

From the ultimate analysis of many different kinds bituminous coal the per cent. of CO_2 by volume was c culated, assuming complete combustion with differe amounts of excess air, and the results plotted as per ce CO_2 vs. per cent. excess air. The curves for all the co investigated were practically coincident. The column Table 4, showing percentage of excess air, is made up means of these curves. From this the amounts of per pound of combustible are computed as well as t chimney loss in B.t.u.

It will be noticed that, while the value

$$\frac{\textit{Boiler efficiency}}{1 - \textit{stack losses}}$$

varies somewhat in the individual tests, the averages the different series are nearly constant, indicating th

the chimney losses exercise the most important influence in improving the efficiency.

The draft loss through the boiler passages is less for the horizontal two-pass baffling than for the original baffling. The number of complete reversals of the gas stream is the same for the two cases, but the two-pass horizontal baffling offers less resistance at the points of reversal. The resistance of the horizontal three-pass baffling is slightly greater than the original baffling. The most striking features of the tests are the low draft losses and the low chimney losses with the two- and three-pass baffling. The lower chimney losses obtained in the tests with the three-pass baffling tends to confirm the opinion expressed by the authors in other published papers that the rate of heat transmission increases with an increase of gas velocity.

R. H. Danforth: The conclusions drawn by the authors agree in a very interesting manner with those I had drawn from data obtained in quite a different line, i.e., the testing of boilers with oil fuel. The authors refer to the action of high-volatile fuels to the effect that in a given boiler with a fixed grate surface the increase in output, other conditions being similar, is approximately proportional to the volatile matter burned.

With oil fuel we have in effect a condition where all the fuel is burned in the combustion space. This should mean that within reasonable limits a given boiler should be able to produce almost any horsepower desired, with approximately uniform efficiency. I have recently received data of two tests on a small-tube, express-type, marine boiler, burning oil of about 19,300 B.t.u. per lb. This boiler was run first at low rating and then at a rating as high as could be obtained, with the following results, which practically prove the above thesis:

	Low Rating	High Rating
Lb. water evaporated per lb. oil	13 86	12 47
Equiv. evap. f. and a., 212 deg. F.	14.69	13 10
Boiler horsepower developed	382	1727
B.t.u. per lb. of oil	19,300	19,300
Approximate efficiency of boiler and furnace	73 8	66.00

O. Monnett: Speaking from my professional viewpoint, the baffling illustrated in Fig. 1 would prove very smoky indeed. In trying to solve the smoke problem in Chicago, we have often been forced to employ the horizontal system of baffling. This often meets with opposition on the grounds of loss of efficiency and capacity. Not only do the present tests show that this objection is baseless, but I have knowledge of hundreds of other tests which prove the same thing; in fact, in many cases, the conditions were markedly improved by the change. Of course, the horizontal arrangement of the baffles usually causes a greater draft loss through the boiler and, hence, the factor of available draft must be considered.

I question whether the drafts reported in Table 2 were actually obtained. In my opinion a 150-ft. or higher stack would be required to give an available draft of 1 in. in the breeching under the conditions mentioned. It seems probable that some error has developed, due to inaccurate draft gage or mistakes in reading.

❋

Purchasers' Tests of Crude Fuel Oil

By W. B. Perkins

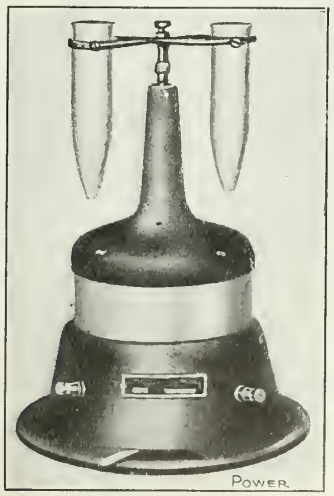
SYNOPSIS—A description of the test methods employed by many central stations using crude fuel oil in the boiler furnaces. The purchase is based on the calorific energy, amount of sulphur, moisture, specific gravity and sediment in the oil.

❋

The method of purchasing crude oil for fuel at a central station where a large quantity is burned each day is based on the calorific energy, sulphur, moisture, bottom sediment in the oil and its specific gravity.

Oil is delivered in cars, pumped from the oil producers, large storage tanks or directly from barges in the harbor. That received in cars is emptied into a long flume leading into a heating and settling tank where practically all the entrained moisture is removed. Just before the work of emptying the cars is started, quart samples are taken from each car at different depths, using a receptacle which may be opened from above the surface of the oil. The percentage of moisture in these samples is immediately obtained with the aid of a centrifuge, a small machine having a high-speed rotating shaft carrying test-tube holders, a view of which is shown in the illustration.

Fifty cubic centimeters of the samples are thoroughly mixed in a graduated test tube with a like amount of gasoline to neutralize the viscosity of the crude oil. The tube is then placed in the motor-operated centrifuge and the machine is run at high speed for approximately 20 min. The centrifugal force exerted upon the mixture throws the heavier parts to the bottom of the test tube. The sand, mud and extremely heavy asphaltic products appear in the point of the tube with the water just above. With the aid of the graduated scale the per cent. of each sample of oil tested is readily observed.



Centrifuge Oil Tester

Any moisture over contract percentage, as shown by the centrifuge, is deducted from the delivery. The specific

gravity, by Baumé scale, and the temperature of the oil when received are also taken, settlement being required if the tests show heavier than 12 Bé. at 60 deg. F. A deduction or addition of 1 deg. Bé. is made for each 20 deg. F. of higher or lower temperature than 60 deg. F. A deduction from the gross quantity of fuel delivered is also made for a higher temperature than 60 deg. F. Samples are also set aside for more complete analysis later.

If the oil is being pumped to the power company's property from barge or storage tank, samples are taken from the pipe line every hour. Each sample is subjected to the centrifuge test, also for temperature and specific gravity. A part of each sample is poured into a small can for future analysis.

Table 1 gives the results obtained from hourly tests.

TABLE 1

Time of day	Temp. F.	Specific gravity Bé.	Moisture per cent.	Bottom of sediment per cent.	Moisture and sediment per cent.
7 a.m.	78	18 00	1 0	1 2	2 2
8 a.m.	79	17 75	1 5	1 3	2 8
9 a.m.	77	18 00	0 5	1 0	1 5
10 a.m.	80	18 25	0 7	1 4	2 1
11 a.m.	79	17 50	1 0	1 1	2 1
12 m.	77	18 00	1 2	1 0	2 2
1 p.m.	80	18 30	0 8	0 9	1 7
2 p.m.	78	17 80	0 9	0 8	1 7
3 p.m.	79	18 00	1 0	1 2	2 2
Average	78 5	17 95	0 95	1 1	2 05

From the foregoing the specific gravity at 60 deg. F. equals 17.03 deg. Bé. scale, and the temperature deduction expressed in per cent. is 0.9.

The quantities determined in the laboratory analysis are: Flash point, deg. F.; specific gravity, Bé. and international degrees, at 60 deg. F.; moisture, per cent.; sulphur, per cent.; B.t.u. per pound as received, and B.t.u. per pound dry.

The methods used in determining the above are outlined herewith. For moisture test approximately 50 grams of oil is placed in a 100-c.c. flask communicating with a condenser and finally a carefully graduated test tube. Heat is applied to the flask until all of the moisture has been distilled and a small amount of the lighter oils begins to collect on top of the water in the test tube. The moisture is then read directly.

Generally, the centrifuge test shows a larger percentage of moisture than the distillation method, because the laboratory samples are usually allowed to stand for several days before being analyzed, thereby giving the particles of moisture opportunity to separate themselves from the oil and collect on the bottom of the containing vessel. Repeated shaking apparently does not remedy this fault. For this reason, the results of the centrifuge tests are accepted as being correct in settling claims for deduction for moisture over 2¼ per cent.

For the calorific determination, approximately ½ gram of oil is placed in an Emerson bomb calorimeter, and oxygen applied until a pressure of about 300 lb. is reached in the bomb. The charge is then exploded with a jump spark and the heat units per pound calculated from the rise in temperature of the water bath surrounding the bomb. Knowing the percentage of moisture, the B.t.u. per pound of dry oil may be readily calculated.

For the sulphur determination, the bomb of the calorimeter is opened after the test for heat units has been made and the residue washed out with distilled water. The washings are titrated and barium sulphate is precipitated by adding barium chloride. The per cent. of sulphur is readily calculated when once the barium sulphate is weighed.

A Westphal balance is employed in the laboratory in determining the specific gravity of the fuel oil. The flash point is reached by heating approximately 30 grams of oil in a crucible, surrounded by a sand bath, beneath which is placed a bunsen burner. A jump spark is passed over the surface of the oil every few seconds, after the 100 deg. F. point is passed.

Table 2 contains the results found in making a laboratory analysis of crude fuel oil.

TABLE II

Flash	= 158 deg. F.
Sp. gravity	= 16 8 deg. Bé.; 0 965 International System.
Moisture	= 0 8 per cent.
Sulphur	= 1 3 per cent.
B.t.u. per lb. as received	= 18,265
B.t.u. per lb. dry	= 18,364

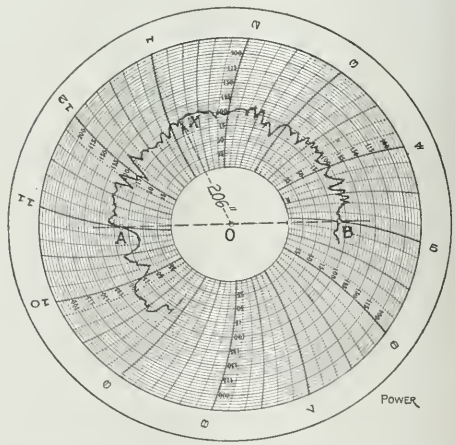
The foregoing method of purchasing crude oil for fuel is used by many gas and power companies where liquid fuel is the only heating agency employed. It has given satisfaction in nearly every instance and may be relied upon.

The Polar Planimeter on Circular Charts

By Julian C. Smallwood

SYNOPSIS—How to obtain the average pressure of circular charts with a polar planimeter.

The ordinary polar planimeter may be used to obtain approximately the average value of the quantity shown by a circular chart from a recording instrument. If the diagram is for an entire revolution of the chart, the area in square inches included by the diagram should be found with the planimeter, the gap at the ends of the curve



How to Use the Planimeter on Circular Charts

being closed with radial lines. This area should be divided by 3.1416 and the square root of the quotient obtained. The result is the average height in inches of the curve from the center of the chart. To put this as a formula,

$$\text{Mean height (in.)} = \sqrt{\frac{area}{3.14}}$$

The quantity wished is now found by noting the value

of a division at a distance from the center of the chart equal to this mean height.

If the diagram is for a period of time less than that corresponding to a full revolution, the formula becomes

$$Mean\ height\ (in.) = \sqrt{\frac{area}{3.14 \times F}}$$

F being the fraction of a complete turn made in the time considered.

Referring to the accompanying chart, suppose it is wished to find the average pressure as shown by the chart between eleven and five o'clock. A line from the points A and B is drawn to the center O. The area included between this line and the recording line is found by the planimeter to be 6.65 sq.in. In describing the recording line between A and B, the chart has made one-half a turn. Therefore, by the second formula,

$$Mean\ height = \sqrt{\frac{6.65}{3.14 \times \frac{1}{2}}} = 2.06\ in.$$

The pressure corresponding to 2.06 in. is found by measuring that distance on any radial as OX, and is 97 lb.

The result is only approximate because it is the square root of the mean of the squares of the radii instead of their arithmetical mean. The distinction between these means may be shown more clearly by the following examples:

8	$8^2 = 64$
9	$9^2 = 81$
10	$10^2 = 100$
11	$11^2 = 121$
12	$12^2 = 144$
$5)\overline{50}$	$5)\overline{510}$
10	102

102 = Mean of the squares;

$\sqrt{102} = 10.09$, the square root of the mean square;

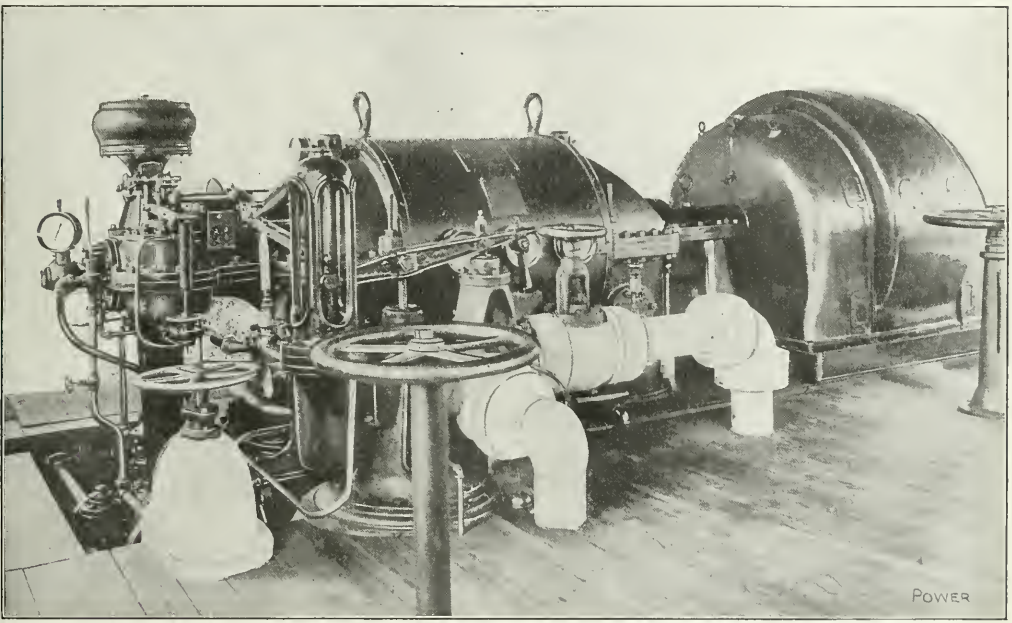
10 is the arithmetical mean.

In this case, the arithmetical mean is about 1 per cent. less than the square root of the mean squares.

Using a theoretically correct averaging instrument on the chart shown, gives a value for the correct average pressure a little less than 97 lb. In general, it may be said that the result with a polar planimeter on such a chart is more accurate, the less is the variation of the quantity averaged; and, except in extreme cases, the error is not greater than 2 per cent.

Saving with Low-Pressure Turbine

An interesting example of the savings which paper mills may effect by using low-pressure turbines, is afforded by the experience of the Smith Paper Co., at Lee, Mass. The primary source of power for the five mills of this company, is the water of the Housatonic River.



Low-Pressure Turbine at Smith Paper Mills

During about one-half of the year the available water is insufficient to develop the required power, and noncondensing steam engines were used to make up the deficit. The exhaust steam from the small engines was used to dry the paper in the various mills, but the exhaust from the seven or eight large engines was entirely wasted. To eliminate this, the company decided to make use of a low-pressure turbine. By replacing five of the reciprocating engines in separate mills by five 200-hp. motors, power is obtained from the exhaust steam at the central mill and is transmitted several miles in each direction at a very small cost. The balance between steam and electrical power in each mill was so fixed that there was

nough exhaust steam available for the heating work ithout any being blown away to the atmosphere.

The necessary equipment, beside the motors and a ransmission line, consisted of a low-pressure Westing-ouse turbine, exciter, switchboard and condenser.

The results obtained by the Smith Paper Co. indicate hat if operated continuously, the installation would save n amount of coal equivalent in value to its own total ost in a period of about two years. In other words, the nvestment in the low-pressure turbines and condenser is ringing a return at the rate of 50 per cent. per annum, nd allowing for the use of the equipment six months in he year, the return is 25 per cent. If used for a shorter eriod the return would be proportional. During a re-ent typical period of three months, for instance, the tur-ine was operated 62 days, due to shortage of water, and eveloped 302,000 kw.-hr. in that time. Charged against he other mills to which it is distributed at 1½c. per w.-hr., this represents a gross earning for the turbine of 4530. The net charge against the machine for that pe-iod was $1400, showing a net saving of $3100 for the hree months.

Automatic Air Pump

An interesting design of air pump has been operating or some time in the mine of the Pittsburgh & Southwest-rn Coal Co., Avella, Penn., for removing mine water. t is the invention of Edwin Chamberlin and A. M. Gard-er, Avella, Penn., who have applied for a patent on the evice, which provides a simple, efficient and automatical-operated liquid-elevating apparatus. A vertical sec-onal view of the apparatus is shown herewith. It con-sts of a tank adapted to be submerged or partly sub-merged in the water to be elevated. It is provided with ater-inlet valves *A* and *B*. A water-discharge pipe *C* piped to the bottom of the tank, and a spring-controlled alve *D* regulates the flow of water through the pipe.

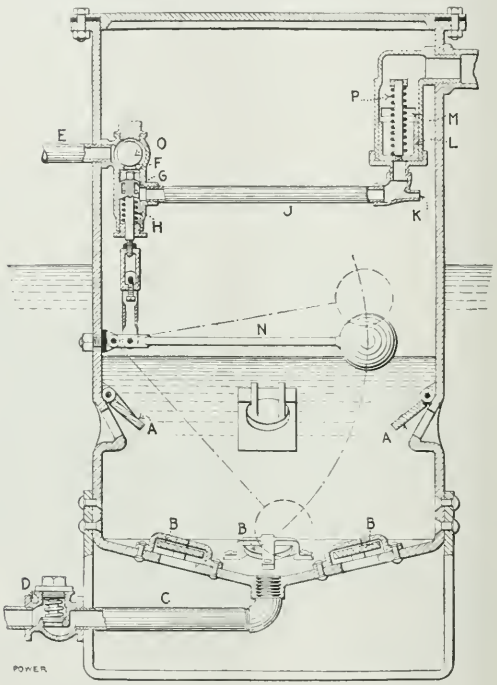
The apparatus is designed for use in connection with ompressed air, which enters through the pipe *E*, leading rom an air compressor, located at any suitable point, an air-inlet valve. This mechanism comprises a cas-ng which is fitted with an interior seat *F*, upon which a all valve seats. The casing is formed with a central bore nd is fitted with a valve *G*, the stem of which passes hrough a plug cap, the latter closing the lower end of he casing and forms a seat for the compression spring *H*, hich keeps the valve stem engaged with the ball valve *O* fter it has been moved upward by the air-inlet, valve-tuating mechanism.

Located on the opposite side of the tank from the inlet alve is an air-exhaust mechanism connected by a pipe *J*. he exhaust-valve mechanism comprises a casing having horizontal outlet chamber and a nozzle, the latter being onnected with an exhaust-air outlet pipe. The lower nd of the casing is capped and connected to the pipe *J*, shown. The elbow is provided with an opening *K*, hrough which the compressed air is discharged into the nterior of the tank.

The cylinder is provided with a spring-controlled lunger which is made with a stem. As the plunger raised the stem passes through a guide. Interposed etween the guide and the plunger is a spring. The cas-ng is provided with a series of ports so designed that when the piston is in its lowest position the passage of air from the interior of the tank to the air-outlet nozzle is permitted. When the plunger is raised by the compressed air, the air ports are closed, thereby cutting off the escape of air from the interior of the tank.

The air-inlet valve mechanism is actuated by means of a float-controlled mechanism, as shown. By means of the adjusting mechanism connecting the valve stem *H* and the rod *N*, the supply of air may be cut off at any desired position of the float, and thus regulate the quantity of compressed air necessary to effectively operate the apparatus.

Assuming that the water or other liquid has entered the tank to a predetermined level, the air-inlet valve *O*



Section through Automatic Air Pump

is raised from its seat by the valve-actuating mechanism, and compressed air passes from the air-inlet valve casing through the pipe *J* to the exhaust valve. The compressed air raises the plunger *L*, thereby closing the ports *M* and preventing the escape of air from the interior of the tank. Simultaneously with the moving of plunger *L*, the compressed air discharges through the contracted nozzle *K* and, expanding, forces the liquid contents of the tank out through the discharge pipe *C*. The descent of the float draws the valve-operating stem *H* down out of contact with the ball valve *O*, when it drops to its seat and cuts off the supply of air to the tank.

After the air has been cut off, the expansion of the air within the tank will force all the liquid in the tank out through the discharge pipe. After the liquid has been discharged, the pressure within the tank is reduced sufficiently to enable the spring *P* to move the plunger *L* down past the ports *M*, which permits the contained air to es-

vape from the interior of the tank, which then fills with water.

By this arrangement a saving in the quantity of air used is made, because the air introduced prior to cutting off the supply will expand and force the water from the vessel.

This pump when properly installed and adjusted to meet the requirements or work assigned, will begin operation just as soon as air is turned on at the compressor, and will continue to operate until the air is shut off or until the water reaches the desired level of drainage, after which the pump will automatically retain that level, using the air only when there is liquid to be raised.

The adaptability of this pump for raising acids, sulphuric mine water, etc., is evident as the intake and discharge valves are made of alloys that will meet with the requirements of the varying conditions. All the other working parts may be located above the liquid to be pumped.

Economizer Losses Due to Scale

By E. R. Pearce

SYNOPSIS—The author shows that the removal of a little scale from the tubes of an economizer decreased the coal consumption by about 6 per cent. It is pointed out that a handful of soda ash dropped into each tube and that kerosene poured on the surface of the water previous to filling the economizer preparatory to boiling for cleaning, will enable one to easily remove exceedingly hard scale.

Recently, on looking through some test figures, the writer was quite surprised at the low temperature of the economizer-outlet water compared with the sizes of economizers and flue-gas temperatures, especially in one case where the feed should have been fully one hour in passing through the tubes. Readings were then taken on one set containing 192 tubes, the capacity of which is stated by the makers to be 12,000 lb. per hr. The heating surface is 1920 sq.ft. This economizer is smaller for the plant than recommended, but extension in this particular plant is out of the question at present.

The averages of a number of readings are as follows:

Flue gases entering economizer	710 deg. F.	Drop 130 deg. F.
Flue gases leaving economizer	580 deg. F.	
Water entering economizer	156 deg. F.	Rise 79 deg. F.
Water leaving economizer	235 deg. F.	

Approximate weight of water passing per hour, lb. 24,000.
Coal burned per hour, lb. 3287.

After these readings the caps were knocked in and a fairly hard scale exposed, composed of clays, vegetable matters and mill refuses, and varying in thicknesses of from $\frac{3}{16}$ to $\frac{5}{16}$ in. at the top of the tubes to ½ in. at the bottom. After carefully scraping there was still ⅛ in. of hard scale remaining which the hand scrapers would not take off. It was then decided to soften the scale as follows:

The blowdown was closed and about 2 in. of water run into the bottom headers, two handfuls of soda ash were next dropped down each tube, followed by a small quantity of coal oil which was allowed to run down the sides of each tube over the scale, a small quantity of the oil was also dropped on the surface of the water in the bottom, the water was now allowed to flow in very slowly, which in rising caused the oil to make contact with all the scale. After this the damper was cracked to allow a little of the gases to flow through and gradually bring the water to a boil (all windows being open and lights kept away). The boiling was continued from Saturday until Monday morning, water being added from time to time. On Monday the remaining scale was scraped off quite easily, a fair quantity having dropped off during the boiling.

There is one point upon which the writer would advise anyone trying the above to be very careful about, viz., while the economizer is boiling, one end, that is, the end nearest the inlet damper, will be considerably hotter than the outlet, owing to the damper being open but very little, and as the water will not have a good chance to circulate, slugs of water will be shot out of the open tube ends at the hottest point every few minutes, rising several feet, and the reader can take the writer's word for it that this water is highly capable of scalding. After cleaning and boiling, another set of readings was taken, the averages of which are:

Flue gases entering economizer	694 deg. F.	Drop 154 deg. F.
Flue gases leaving economizer	540 deg. F.	
Water entering economizer	156 deg. F.	Rise 136 deg. F.
Water leaving economizer	292 deg. F.	

Approximate weight of water passing per hour, lb. 24,000.
Coal burned per hour, lb. 3088.

From these figures it will be seen that a rise of 136 deg. F. was obtained which is an improvement of 5.5 per cent. on the first set of readings.

During both sets of readings which were taken over a period of ten hours the load was practically constant. A gain of a little over 6 per cent. is shown in the coal consumption.

Considering the amount of water passing through the economizer per hour the heat transferred per square foot of surface is good, amounting to

$$\frac{24{,}000 \times 136}{1920} = 1700 \text{ } B.t.u. \text{ } per \text{ } sq.ft. \text{ } per \text{ } hr.$$

In the other set containing 320 tubes the temperatures were very low, only a little better than is possible with a good open heater. On opening up the economizer the tubes were found to be reduced in water space to less than one-half, in fact, there was only a hole of about 1¼ in. diameter at the bottom ends of many tubes.

The Bridge River Co., a recently incorporated Canadian concern, has applied to the provincial government for water rights aggregating 100,000 ft.-acres in the Lillooet district on Bridge River for developing at least 200,000 hp., at a cost of $8,000,000. A large dam is to be built and the water carried through a ¾-mile tunnel to Seaton Lake, where the power plant will be built. The company has taken into consideration the future requirements of Greater Vancouver and the possibility of electrification of the coast section of the Pacific & Great Eastern Ry., which is to run north from the Pacific coast of British Columbia, to connect with the Grand Trunk Ry. at Fort George. The proposed power line will follow the route of the Pacific & Great Eastern Ry. for about 150 miles. As the power house will be less than 50 miles from the main lines of the Canadian Pacific and the Canadian Northern at Lytton, the projectors hope also to be able to sell motive power to these two roads. Work is expected to begin on this project before the end of this year and will take probably three years to complete.

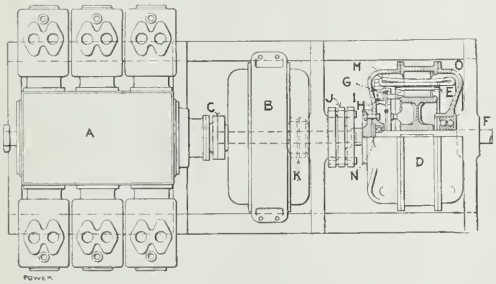
The Manchuria Ry. Co. operates five coal mines, which give employment to 7000 Chinese laborers, who work for 25c. per day. The output is 300 tons for each mine per 24 hours. Though the coal is bituminous, anthracite methods of mining are used, as the seam is too thick (125 ft.) to make bituminous methods practical.—"Coal Age."

ELECTRICAL DEPARTMENT

The "Paragon" System of Electric Drive

By Arthur H. Allen

W. P. Durtnall, the inventor of the "Paragon" engine, described in the Feb. 18 issue, and of the "Paragon" system of propulsion for ships, locomotives, etc., has devised a new and ingenious method of propulsion for motor vehicles in which are embodied the advantages of the gasoline engine and electrical transmission and control. An essential feature of the system is the fact that the engine is always run at its most economical speed; three economical running speeds are provided, and reverse, and a flywheel is dispensed with, its function being filled by the revolving parts of the electrical machines.



Plan of Paragon Transmission

The accompanying illustration shows the arrangement of the mechanism, which consists of a six-cylinder horizontal "Paragon" engine *A*, with ball bearings; a three-phase, four-pole alternator *B*, and a "clutch-motor" *D*. The engine runs at 800 r.p.m. and drives the rotor of the alternator through a coupling *C*, as well as the outer part of the clutch-motor; the inner part of the latter *E*, is a squirrel-cage rotor of the ordinary type, fixed to the shaft *F*, which is carried in journal ball bearings and the centering ball bearing *N*. This shaft is coupled in the usual way to the driving gear, with a simple reversing gear consisting of two bevel wheels always in mesh, one with each side of the driving pinion; a dog clutch mounted on a squared part of the main axle, and operated by a fork and lever, brings either pinion into action, according to the direction of motion required.

Inside the clutch-motor case there is a magnetic clutch, of which half is shown at *G;* this is energized by the exciting coil *H*. When the magnetic clutch is in operation, the engine drives directly on to the shaft *F*. Slip rings are shown at *K*, by means of which the exciting current is conveyed to the revolving field of the alternator. Other slip rings *J* are connected through the hollow shaft with the eight-pole, three-phase winding of the clutch-motor case, which is exactly like the stator of an induction motor, but in this instance is not stationary. The mode of operation is as follows:

The engine is constantly running at, say, 800 r.p.m., and drives the revolving field of the alternator, together with the two sets of slip rings and the outer case of the clutch-motor: assume that the rotation is counter-clockwise. For the first speed, direct current is supplied to the slip rings *K* from a small exciter, not shown. Three-phase current at 25 cycles is taken from the alternator armature and delivered to the slip rings *J*, which are connected to the eight-pole winding *M*. The three-phase connections are such that the magnetic field revolves in a clockwise direction at 400 r.p.m., while the winding revolves at 800 r.p.m. in the counter-clockwise direction, so that the resultant rotation of the magnetic field is counter-clockwise at 400 r.p.m. The squirrel-cage rotor, therefore, starts and runs up to approximately synchronous speed, driving the vehicle at, say, four miles an hour.

The next speed is obtained by switching off the exciting current from the field magnet of the alternator, and putting it by way of one of the slip rings and the frame on the magnetic clutch coil *H*, which connects the engine shaft mechanically with the shaft *F*, so that the vehicle is accelerated to twice the former speed, and runs at eight miles an hour, with the maximum economy—no electrical machine being in operation except the small exciter.

The third speed is given by reversing the three-phase connections, releasing the magnetic clutch and again exciting the alternator; the magnetic field now rotates in the same direction as the engine shaft, and the resultant angular speed of the field is 800 plus 400 = 1200 r.p.m., so that the motor runs up to a speed corresponding to 12 miles an hour.

As stated, no flywheel is required, and, owing to the high speed of rotation and consequently effective cooling, the electrical machines are very light for a given output and heating limit. The efficiency of the transmission is very high, the total weight per horsepower transmitted is low, and the mechanism is comparatively cheap. The speed of the vehicle, of course, depends upon the gearing, the example given being merely illustrative. The engine always runs under economical conditions, and the starting torque is very high.

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Welding an Armature Shaft

Some months ago we welded an armature shaft which seemed at first somewhat doubtful of success; but on account of the inability to obtain another armature we tried the experiment. The armature was for a 50-hp. motor running at 1000 r.p.m. The shaft carried a 12-in. pinion, which ran at the high speed of 3150 ft. per min. on the pitch line. As might be expected, the gears are very noisy and wear out frequently, which in turn was responsible for damage to the motor shaft, so that it previously had to be turned from 3½- to 2¾-in. diameter.

The excessive vibration, due to the high gear speed,

ultimately caused crystallization of the shaft and the break at the shoulder. To repair the shaft, we beveled the end of the armature shaft and also the 3⅝-in. diameter block shaft, which was to be welded, starting the weld from the center and being careful not to cause blisters. After allowing it to cool, the shaft was turned down to 3⅜ in. and keyseated (the gear wheel having been bored larger meanwhile). In this way the machine was out of commission slightly over 24 hr. So far the weld has not given any indication of weakness, although the machine has been doing heavier work than before the time of the accident. Of course, the weld may not be quite as strong as the hammered portion of the shaft on account of the coarser grain, but a 3⅜-in. diameter shaft is 80 per cent. stronger than one of 2¾-in. diameter, which was the size which broke.

Where breaks of large cross-section are to be welded by the oxyacetylene process they should be heated by a gas or oil burner before starting to weld, as otherwise the weld will crack upon cooling.

Bellevue, Penn. J. L. KLINDWORTH.

New Line of Westinghouse Motors

The new line of Westinghouse type CS squirrel-cage induction motors possesses several noteworthy features, among which are the extensive use of pressed steel in the construction and rotors with cast-on short-circuiting rings. Pressed steel imparts great mechanical strength and is very uniform in structure; hence a motor of a given weight can be made with more active material than motors of corresponding capacity in cast-iron frames.

In these motors, rolled steel forms the frames of the sizes above 20 hp., the end plates of the smaller sizes (which are of the so called frameless type) and the feet

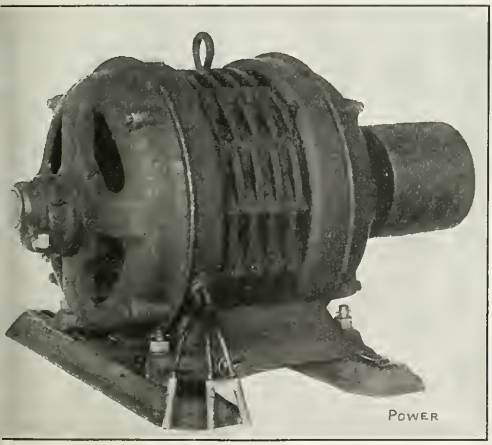


FIG. 1. A 10-HP. MOTOR

and the slide rails of all sizes. Above 5 hp., the form-wound stator coils are laid in open slots.

The rotor construction is especially interesting. In all sizes, the rotor bars are insulated with a special cement which is moisture proof and will withstand a high degree of heat and mechanical stress. In motors above 5 hp., the bars are connected electrically and mechanically by casting the short-circuiting rings around their ends.

The bearings, being the only wearing part, have been designed very liberally. They are protected from dust

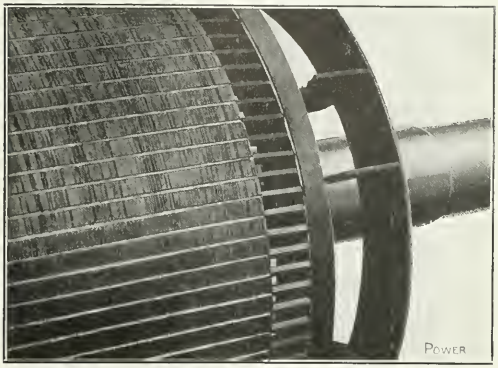


FIG. 2. DETAIL OF ROTOR

by a cap on the front end and by felt washers between metal rings on the pulley end.

The efficiency and power factor are claimed to be high, not only at full loads, but also at fractional loads. This last feature is of special importance because industrial motors generally run at less than full load. These motors are being put on the market in all commercial sizes from 1 to 200 hp.

Care of Storage Batteries

In the article on the "Installation and Care of Storage Batteries" in the July 22 issue, the instructions about taking the battery out of service are not, in the writer's opinion, in accord with present-day practice. The statement in question is that the battery must first be discharged and then the electrolyte removed from the jars and water put into them, after which the battery must be still further discharged and then the water drawn off.

It was formerly the custom to do this, on account of the action on the wood separators, but experience and improved methods of treating the separators have shown that the following method, which is approved by one of the largest battery manufacturers, is better:

When about to lay up the battery, first thoroughly charge it and then siphon off the electrolyte into clean receptacles of glass or earthenware, and as each cell becomes empty, immediately fill it with pure water and allow all of the cells to stand for about fifteen hours, after which the water may be drawn off and the battery may stand indefinitely.

The use of storage batteries has become so common of late that many engineers have them in their plants, and even if a man comes into a plant where there is a battery and is unfamiliar with the operation of the battery, the manufacturer is usually ready to help him with advice and personal aid; and if he makes no important changes without consulting them until he has learned all about the characteristics of the battery he will have no trouble.

East Dedham, Mass. G. H. KIMBALL.

[The discharge method is still advocated by many authorities.—EDITOR.]

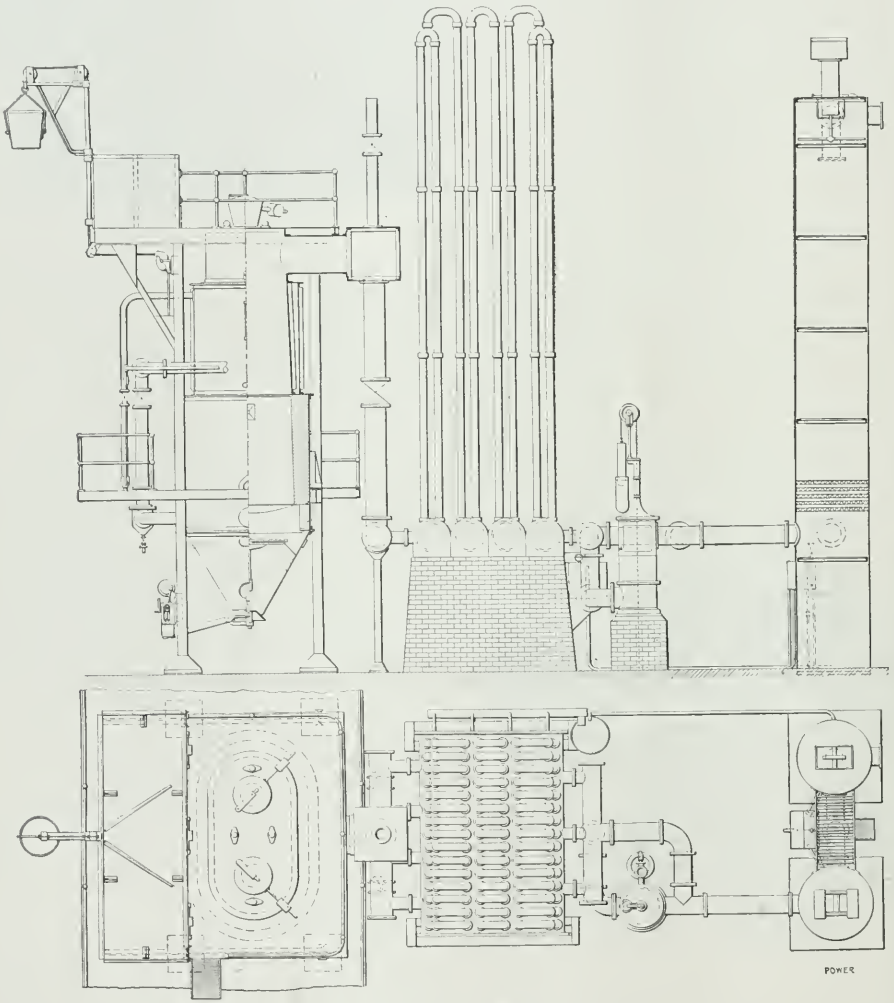
GAS POWER DEPARTMENT

A New Byproduct Recovery Producer

By James A. Seager

During combustion of coal in gas producers in the presence of considerable steam, a large part of the nitrogen content of the fuel enters into combination with the hydrogen of the steam, forming ammonia. The decomposition of ammonia by heat is, however, very easy, and the temperature has to be kept down to prevent it from being wasted.

The method usually adopted to keep the temperature down is to admit to the producer a great excess of steam, this being a wasteful procedure from various points of view. The ammonia has to be recovered by an acid process as any scrubbing plant capable of dealing with the large volume of gas and steam leaving the producer would be excessively large and costly. The ammonia salts obtained from such an acid process, moreover, often have a bad color and the tar obtained is not of the best quality. In addition to all this the development of



Plan and Elevation of Moore Producer

such an excess of steam requires a larger steam-generating plant than would otherwise be necessary.

These disadvantages, therefore, add interest to a new type of water-jacketed producer with byproduct recovery, designed and constructed by the Dowson & Mason Gas Plant Co., Ltd., of Manchester, Eng., an elevation and plan of which is herewith shown. The fundamental principle underlying this new development is the separation of the gas production into three stages in the producer itself. The lowest portion of the producer consists of a region in which a high temperature is maintained, the fuel being treated in a compartment lined with firebrick and here the greater part of the gas and ammonia are generated; the amount of steam admitted is strictly that excess necessary to prevent the temperature rising beyond the proper value.

Above this high-temperature region is a second or intermediate temperature section where the producer is not lined with firebrick but is water-jacketed, and here the gas which has been generated in the lower part of the producer is cooled to prevent decomposition of the ammonia. This cooling process is equivalent to the introduction of a large excess of steam in the older process. It will be seen that in order to insure this cooling effect the internal diameter of the producer which is slightly conical is rather less compared with its height than is usual in ordinary producer practice.

The third region, in which the process is carried a stage further, allows for air cooling; but there is no definite line of demarkation between the second and third regions. The feed of the coal is not intermittent, as in many types of producers, but is continuous through a special gas-tight feeding apparatus, and the ashes are withdrawn by means of two circular-coned tables, one on either side of a grate built up in halves. It will be noticed that the usual water bottom is eliminated.

The water jacket serves as a steam generator supplying most of the steam required for operating the plant. It is stated that a 300-hp. plant is capable of working at 1¼ lb. of coal per brake horsepower-hour and this will evidently yield a good return on the capital invested providing that favorable conditions exist for the disposal of the byproducts.

The producer, as will be seen from the foregoing remarks, possesses advantages over the ordinary recovery producer. The conical shape allows for the expansion of the coal during the coking stage, and facilitates the natural descent of the coal; hence about 50 per cent. more coal is said to be gasified for the same sectional area as compared with the ordinary byproduct recovery producers having a vertical shaft. The double function of the water jacket is also important. It rapidly cools the ascending gases formed in the brickwork portion of the producer, thus preventing the decomposition of the ammonia and it also provides about half the steam required for the saturation of the air blast. This total amount of steam is about one-third to two-fifths of that required for the production of ammonia in ordinary recovery producers (about 80 to 90 lb. of ammonia per ton of coal). The amount of steam decomposed in passing through the producer is approximately 20 per cent. in excess of that decomposed in ordinary recovery producers working at the same blast temperatures. Another feature is that the temperature of the gas in leaving the producer is very low—in the neighborhood of 200 deg. C., which besides improving the efficiency of the producer itself, also simplifies the auxiliary cooling and recovery plant necessary to the process. Moreover, the gas, after the extraction of tar and ammonia, leaves the plant at little above atmospheric temperature, and is practically free from moisture.

The calorific value of the gases, when the plant is being worked under conditions which allow the recovery of from 80 to 90 lb. of ammonia per ton varies from 155 to 160 B.t.u. per cu.ft. The average analysis of the gas obtained may be judged from the following:

CO_2	CO	H_2	CH_4
per cent.	per cent.	per cent.	per cent.
9 to 10	20	20	3

It has been found possible by reducing the quantity of steam, to obtain a gas containing 25 per cent. or more of carbon monoxide, although this gain is at the expense of a reduction in the ammonia yield. On the other hand, where the quality of the gases is of less importance, it is possible to obtain a much greater yield of ammonia than 80 or 90 lb. per ton of coal.

Summarizing the features, it may be pointed out that the claims of this new producer known as the "Moore" type, are that after allowing for producer loss and the heat required for steam raising, the net available quantity of gas is 20 per cent. more than that obtained from ordinary recovery producers. This would make the first cost of the plant less. Moreover, the ground space required per unit is about half that required for the ordinary recovery plants and operating costs are said to be considerably less.

The live-steam requirement calculated on the total coal gasified in the producer amounts to 8.5 per cent. The feeding of the coal is constant and regulated by the rate of ash extraction, the latter in its turn being regulated by the rate of gasification. The tar is extracted after the gas is cooled by passing through air condensers by the well known Plouze and Audouin apparatus and the ammonia is scrubbed out with water from the gas and recovered as ammoniacal liquor. By recovering the ammonia in this form either concentrated ammonia or ammonia salts can be manufactured as required.

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To Make German Engines

The American Krupp System-Diesel Engine Co. has been incorporated under the laws of Delaware to manufacture and sell Krupp-Diesel engines. The company has secured the exclusive rights for the United States and its territorial possessions to all inventions, patents, trade marks, etc., of the celebrated German concern, The Fried. Krupp A. G. of Essen, Magdeburg and Kiel, in so far as the same relate to oil engines and especially to the Diesel engine.

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There is no falling off in the building of large gas engines in Germany. Thyssen, at Mulheim, has 60 on order, none of which is under 2500 hp., and is turning out one a week. The Augsberg Nürnberg Maschinenfabrik has over 700,000 hp. of big engines running on blast-furnace gas, and reports no falling off in orders for such engines. The greater cylinder diameter is 1400 mm. (55 in.), and the largest engine 6000 hp. in four cylinders.

REFRIGERATION DEPARTMENT

Corrosion in Refrigerating Systems

By Morgan B. Smith

During the past eight years the writer has been called upon to investigate many cases of corrosion in refrigerating systems during which time he has been able to isolate certain factors which exert an accelerating force upon that natural tendency of metal, especially iron, to return to the original condition of nature through the process of corrosion or oxidation.

One of the greatest factors entering into this action is that force set up between electrically dissimilar metals known as auto-electrolysis, or, in the older diction, galvanic action.

In the first place it seems best to give a short table, showing the relationship which exists between those metals commonly entering into the make-up of refrigerating system, in order that the action which ensues between electrically dissimilar metals may be understood. In combinations of such metals it is always the positive metal which is attacked and so eventually destroyed. In the following table the most positive metal is given first. Each metal is positive to the one following it and negative toward the one preceding it, as a rule:

1.	Aluminum	5.	Iron	9.	Copper
2.	Chromium	6.	Nickel	10.	Hydrogen
3.	Manganese	7.	Lead	11.	Silicon
4.	Zinc	8.	Tin	12.	Carbon
				13.	Phosphorus
				14.	Sulphur
				15.	Chlorine
				16.	Oxygen

From this table may be derived the electrolytic relation between any two of the metals given. Simple contact of any two metals in this series will generate an electromotive force (e.m.f.). The greater the separation of the two metals in this table the greater will be the e.m.f. set up between them. In the presence of moisture or an electrolyte auto-electrolysis or galvanic action will be set up and the positive metal destroyed.

Of those elements noted in the table, iron, copper, copper-tin (brass) and zinc probably play the larger part in refrigerating plants. The other elements given, with the possible exception of aluminum which in the future is sure to come into more general use in refrigerating plants, are usually present as impurities in the metals used in the construction of such apparatus.

In the matter of combinations of dissimilar metals, not merely the union of separate pieces of unlike metals, such as iron with copper or iron with brass, etc., but also the union which exists between metals and the impurities in those metals, as, for example, that contact which exists between iron and carbon, iron and phosphorus, iron and sulphur, iron and mill-scale, etc.

It is apparent, therefore, that not merely must the union of separate pieces of unlike metals and the union of the metals with their impurities be considered, but also the state in which those impurities exist in the metals.

As a matter of fact, there are only two conditions which need be considered, namely, that of true alloys in which the original metal and the alloyed metal have each lost their individual identity and so act as one metal, in which case, strictly speaking, the added metal is not spoken of as an impurity; and, secondly, that condition in which metals other than the basic metal are present in mere mechanical contact with the basic metal.

The iron-copper alloys represent the first condition well and cast iron the second. In the case of the iron-copper alloys, both the iron and the copper have lost their identity as such, whereas in the case of cast iron, or for that matter, wrought or malleable iron, in a somewhat lesser degree, the iron still retains its identity as such; likewise the impurities in it, such as carbon, silicon, phosphorus, sulphur, etc.

In the case of the alloys the metals composing them are no longer free to act upon one another; whereas in the case of cast iron, the basic metal and the impurities are still free to act upon each other, setting up within the metal local zones of electrolytic action where corrosion takes place more or less rapidly at the expense of the iron.

These local electrolytic centers also arise around particles of mill-scale (oxide of the metal) which acts electro-negatively toward the metal and so hastens the destruction of the metal itself.

It is now apparent that the distribution of these impurities in the basic metal will have much to do with the character of the corrosion, determining to a large degree whether the corrosion is to take place locally or in general throughout the metal. If the impurities are evenly distributed in the basic metal, corrosion will take place uniformly, resulting in an even wearing away of the metal, likely to give a fair length of life.

If, on the other hand, the impurities are segregated, or gathered together, in fairly well defined masses, corrosion will take place at these points principally, resulting in pitting or grooving of the metal, in which case the piece of metal will fail at these points long before the real life of the metal has been reached.

It is, therefore, safe to conclude that so far as possible combinations of dissimilar metals should be avoided; that metals of the highest degree of purity should be used and that metals showing the least degree of segregation of their impurities should be selected. Likewise, that the alloys offer a possible means of avoiding local or auto-electrolysis in metals.

In practice during the past eight years many instances of obviously bad practice have been noted, among which are the following specific instances:

1. Brass valves joined with wrought-iron nipples or pipe. The iron is attacked in this case.

2. Cast-iron fittings joined with wrought-iron nipples or pipe. The wrought iron is usually attacked more rapidly than the cast iron, although it too is eventually destroyed.

3. Brass glands, etc., in cast-iron-bodied pumps. In this case the iron is eventually destroyed.

4. Galvanized iron joined with brass valves. The iron is here destroyed rapidly, even though the iron has

been re-galvanized after threading, for the zinc is even more strongly electro-positive toward brass than is iron.

5. In many cases the use of galvanized-iron piping where there is much moisture and a free circulation of air has proved to be bad practice, especially if the quality is not the best, where there are many pin holes in the zinc coating. The zone of protection afforded iron by zinc in galvanized iron is comparatively restricted and, inasmuch as this protection is given at the expense of the zinc, it is obvious that the more iron is exposed the faster will be the destruction of the zinc, zinc being electro-positive toward iron.

6. Steel piping joined with cast-iron fittings. In which case the steel piping or nipples will be attacked first, the cast iron also showing attack.

7. Steel piping joined with brass valves or unions. In which case the steel is attacked vigorously.

8. Copper vessels to which are attached iron or steel pipes or fittings, as in some breweries. The iron again is attacked.

9. Iron or copper piping made up with red or white lead at the joints. As a rule, corrosion of the iron or copper may be expected after a time, especially in brine lines. Flanged joints should always be used in preference to screwed joints wherever practicable.

10. Aluminum joined with copper or brass. In which case corrosion of the aluminum will take place.

These instances are given to show concrete instances in which corrosion has actually taken place with resultant destruction of the positive metal. They are not merely conjectures but are actual conditions noted in practice.

In the consideration of this topic there are several conditions which are almost always present, among which are: First, a condition of strain; second, a condition of accelerated oxidation caused by the presence of oxidizing agents, such as air, and, third, a condition of accelerated corrosion caused by the effect of stray electric currents.

Strain, whether tensile, transverse or torsional, in metal always (without exception so far as is now known) sets up a difference of potential between two unlike metals joined or between a metal and its impurities. This is especially true of torsional strain.

In joining unlike metals, if there is no feasible method of avoiding such practice, great care should be taken to insure the least possible straining of the two metals. When a screwed joint is made up snug and tight there is inevitably a tremendous torsional strain set up throughout the metal and especially at the weakest portion, namely, the threads. When a flanged joint is made up no such strain occurs in the flanges, although the bolts and nuts are subjected to the same strain as in screwed joints. In fitting the flanges to the pipe ends care should be taken not to induce very great strain as here again there is the case of threads to contend with.

It seems to be excellent practice to use extra-heavy piping and fittings wherever practicable, even though the first cost is much greater. Such heavy fittings stand the strains far better than ordinary weight fittings and also make tighter joints with far less danger of leaks.

Accelerated oxidation or corrosion is often caused by the fact that piping is so set up that air accumulates at the top of fittings and in apparatus as well. Piping should be so put up that it may be vented at high points and so completely filled with the liquid which it is conveying. This is likewise true of apparatus in general. Oxidation or corrosion of this nature is always hastened if there are present combinations of dissimilar metals or metals possessing high amounts of impurities or segregation of impurities.

The action of the electric current in promoting and accelerating corrosion is so well known as to require little comment. It is well, however, to again point out that this action is always accelerated in greater degree in the case of combinations of dissimilar metals than in the case of single metals, especially in the presence of an electrolyte or moisture. In hunting down the sources of such currents it is well to bear in mind the fact that it is usually the smallest currents which in the long run cause the most damage, because they are allowed to go on in their action until at last the effect is noted in the failure of metal.

As to the proper combinations of metals in refrigerating systems there can be no fixed rule, because, as mentioned above, there are so many variable conditions present that what is good in one case may prove undesirable in another. However, there are certain combinations which seem in general to be good practice, namely:

1. Malleable-iron fittings with wrought-iron piping or nipples, as opposed to the use of cast-iron fittings.

2. Copper or brass valves or unions, etc., joined with iron but insulated by means of a heavy shellac or varnish used in making up the joints. Such means have proved successful in a number of instances, as opposed to direct contact of copper or brass with iron.

3. Cast-iron fittings and cast-iron piping.

4. Where it is necessary to join unlike metals without insulation it is good practice to use short fittings either side of the valve or second-metal fitting, i.e., in the case of a brass valve in iron pipe lines it is well to use short iron nipples or flanges at each side of the valve so that when the iron is destroyed it will be necessary to restore only these short pieces rather than whole lengths of pipe.

5. In many cases it has been noted that iron galvanized by the sherardizing process may be successfully joined with ordinary iron or even with copper and brass, whereas iron galvanized by the hot or electrolytic processes is usually destroyed under such conditions. This is probably caused by the fact that the coating on iron in the case of the sherardizing process is not pure zinc but rather an alloy of iron and zinc. At any rate it seems to be far more resistant to the action of auto-electrolysis than the usual coating of zinc.

6. Aluminum, a metal which in many solutions, including brines, actually gains in weight because of the fact that it oxidizes and retains a firmly adherent coating of the oxide, seems to have been overlooked in the design of refrigerating plants. It may be safely joined with iron, especially wrought or malleable iron, in almost every condition met with in refrigerating plants. Any action, however, which may be set up will take place at the expense of the aluminum in the case of a combination of iron and aluminum. Aluminum cannot be safely joined with copper or brass.

7. Steel pipe which has been treated in such a manner as to eliminate or at least distribute evenly the mill-scale may be joined with wrought iron or cast iron safely as a rule. It cannot be joined with copper or brass safely. The same stock without treatment for the mill-scale will

show a decided tendency to corrode when joined with wrought or cast iron. The so called "spellerized" steel fulfills this condition with respect to the scale.

There are, no doubt, many other combinations which work out well in practice under certain conditions. The above named combinations are in actual use successfully at the present time and for this reason only have they been given. The writer is of the opinion that not sufficient attention has been given to the matter of insulating joints between dissimilar metals. It seems highly probable that in the future more attention will be paid to this as it ought to solve the problem, at least partially, of combining electrically dissimilar metals in the presence of electrolytes.

A Factor in Ice-Plant Efficiency

By Peter Neff

To anyone who has occasion to examine ice plants, there are some things which impress him immediately, and which serve as an index to the character of the manager and the engineer in charge. If the purpose of the examination, for example, is to assist in correcting some disorder affecting the capacity of the plant, information will naturally be sought from those having the plant in charge. If upon entering the plant everything is found in disorder, and the engineer dirty and slovenly, one's thoughts pass to the manager who will permit such a condition to exist, and the conviction comes that what statements they may make will have to be discounted, and it will be necessary to seek the information for one's self.

In such a plant if one asks for a piece of waste, he will usually get a dirty piece from the engineer or a rag, and in many instances there is no such thing about. No records of value are likely to be found. The manager may make a statement which the engineer will deny, perhaps not to his face but when alone with you. It is a most difficult thing to assist such a plant and it is not to be wondered at that it is not successful.

On the other hand, if everything is in order, wrenches where they belong, machinery and floor clean, engineer neat and "here take this piece of clean waste, you may need it; and if you want to go there, better put on a suit of my overalls, there is a clean set there in the locker," and when you have finished there is soap, a place to wash, and a towel; you instinctively know that the information desired will be forthcoming and in such shape as not to be contradicted; the manager will be in accord and will tell you that the engineer knows all about this or that.

The engineer of an ice plant must be far above the man who simply looks after a boiler and engine, and yet that is what some managers believe is the engineer's sole work. True, he has both of these things to do, but much more; there is the usual assortment of pumps and electric equipment; then there is the compressor, not only must he know its construction but its functions as well if he would keep it up to its maximum efficiency. The ammonia condenser to some is only a set of pipes with water over them, to the engineer it is an apparatus governed by the laws of heat transmission, and something that can do much or little depending on its condition. He will see that the ammonia leaving it is as cold as possible and will know how to accomplish this. Having made the condenser do all it can, he will see that the temperature of the ammonia is not raised after it leaves the condenser, and if the liquid receiver is placed in a hot location, he will correct this loss. Should he have a little well water and yet not enough for all purposes, he will use this for the final cooling of both the ammonia and the water to be frozen, thereby saving on the work that the compressor has to do. The ice tank will be a constant study to him, to see that the insulation is in good condition, that the circulation of the brine is the best that can be gotten, that the ice is pulled and the filling of the cans done regularly so as to avoid losses. He must know what will affect the character of the ice and see that it does not occur. He will see to it that records are kept and will check them so that he knows what goes on in the plant all the time, and can refer back to them. If he finds, for example, that for an hour or two in the night the steam pressure went down, causing the water pump to slow up and the condenser pressure to advance in consequence, and that the net results were increased fuel consumption and a decreased amount of ice made, he will be in a position to demand an explanation, and he will make no mistake in placing the responsibility.

At the end of each month he will examine his record for the corresponding month for as many years as he has had charge of the plant. If the month shows a greater production of ice, and less fuel, etc., he will feel that he is on the right track and will say that next year he will beat this year's record.

If, however, this year's record is not so good as the corresponding month the year before, he will not rest until he has found why in such plain language that anyone can understand it.

An engineer must have a desk in which to keep his papers, and the owners should recognize that this is part of the engine-room equipment. If they will not furnish one, the engineer should make one.

Nothing is so satisfactory as to know what the plant is doing, and judging this by comparing it with past records. One would suppose that all engineers would keep complete daily logs of plants in their charge if for no other purpose than to protect themselves. There is nothing more deplorable than where reports are made out without any care and perhaps thrown into a drawer and that is the end. No useful lesson is learned from them and there is no compiling for comparison with other years.

In times of trouble the true engineer is in the thick of it regardless of time, and he does not leave a plant in trouble to another. The thinking engineer today is in demand; he knows what he has done and has hopes and ideals for the future of the plant entrusted to him.

In no other industry perhaps has the engineer such direct control over the affairs of the organization he is serving, for he controls the quantity and quality of the output, and most of the expenditures connected with its production. An increased tonnage and a decrease in operating expenses makes for dividends, and the sooner ice-plant owners realize what the true engineer can do for them, the more they will seek for such a one.

The Third International Congress of Refrigeration is only a month away. From all indications the exhibits will be unusually complete and well worth traveling over half the continent to see.

EDITORIALS

Using Office Help in Slack Time

With so much being published on efficiency, business management and standardization, it behooves the mechanical engineer, like everyone else, to study lessening the waste of time in his office. Almost every business has its slack seasons, and when the work is of a technical nature calling for some special experience, it is impracticable at such times to cut down the staff to maintain the proper balance between output and help. The great problem confronting the office manager or chief draftsman, is how to make the best use of those of his men who are temporarily idle.

One solution is to use this time for systematically collecting and classifying data relative to the business. The engineer's office offers an unlimited and absorbingly interesting field for such a system, as every branch of engineering requires special detailed knowledge. Once all the available data are collected, the process of sifting and classifying would be simple, and the result would be that in busy seasons the work of the men who did the data hunting would be vastly improved. They would have a better grasp of the technique, a knowledge of where to find the data they needed, increased interest, and greater confidence in themselves.

The office manager, on his side, would gain not only an experience of scientific methods in reference work, as well as an easy reference system for future use, but a first-class knowledge of the capabilities of his staff, especially if they had been left to do the work on their own initiative. In teaching the ropes to new men this accumulated experience filed in a card-reference system would be invaluable.

The methods of obtaining the data should be both theoretical and practical. Much valuable information could be obtained by visiting places where power plants or mechanical systems were being installed. This would give opportunity for that comparative study on the practical side which is of first importance to the draftsman when laying out work. This practical work should be supplemented by thorough scanning of current periodical and other literature in the shelves of public and technical libraries, which would show just what is being done by those highest in a particular line of work.

How many young engineers, for instance, know thoroughly the special problems connected with the ventilating, heating, and lighting of factories and workshops? A handful of men are all that have made a special study of this subject, and their writings are, as often as not, found not in the technical periodicals which the engineer has in his office, but in the proceedings of public-health bodies and reform and labor organizations. At present labor and health laws already existing in some states, and soon to come in many others, are making this subject an exceedingly live one for engineers, who in many cases, as yet, are but half prepared to handle in the best manner the special problems such legislation will create for them. This is only one among many engineering subjects in which the collection and systematization of existing data should prove invaluable to the engineer, and above all, to the young engineer with his career before him.

Data must be obtained and often at great speed, in which case it may not represent the best practice. How much better therefore to get it while there is time to spare, and not leave it to be gathered while the job is waiting to be done.

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Foaming Boilers

No doubt every boiler-house attendant some time or other has been troubled with foaming or priming boilers. That this condition is serious is only too often shown by the sudden blowing out of an engine-cylinder head, the breaking of some part of the steam line because of water-hammer, or some other mishaps usually accompanied with more or less danger.

In spite of all claims to the contrary, no boiler—except when equipped with a superheater—will deliver dry steam. This does not necessarily mean that all boilers foam, even though a small quantity of water is carried over into the steam header. It is the amount of water going into the header that differentiates between a priming and nonpriming boiler. In the former large slugs of water are thrown out and carried along in the steam line until they are either captured by a steam trap or delivered into the engine cylinder, frequently resulting in a wrecked engine.

It is also true that a steam-space of ample capacity and in a boiler that is at rest and under pressure will contain practically dry steam. But the moment this boiler begins to deliver steam and to receive heat from the furnace fires, then the water surface becomes agitated and consequently more or less water is thrown into the steam space, a part of which is bound to be picked up and carried away with the steam. While there are dry-pipes, dry-plates, dry-boxes, etc., to prevent this carrying away of the water, nevertheless some water usually will get past. This condition is not serious, however, at least from the standpoint of safety, because of the small quantity involved which can ordinarily be taken care of by proper traps. It is when the large slugs of water are carried over that the trouble begins.

For this reason every attendant of steam boilers should familiarize himself with the several causes of priming; to know how to eliminate them should occasion arise.

Some of the principal reasons for a boiler priming are: rapid changes in the draft of steam or sudden demands for large volumes; defective circulation; restricted steam area; insufficient water area; forcing, or excessive evaporation; dirty water; too much soda ash in the feed water where such is used for purification; presence of oil in the boiler in connection with the use of soda ash for purifying the feed water; and presence of an excessive amount of sludge, sometimes resulting from the use of boiler compounds and graphites.

Some of these causes may be rather difficult to remove, at least without spending considerable money. On the other hand in many instances the wide-awake boiler-house attendant can determine the trouble upon proper investigation and very often apply the necessary remedy.

For example, foaming caused by sudden demands for large volumes of steam would indicate need of a larger steam-storage capacity. This might mean some steam loss from radiation, but very little with proper insulating covering. Then, again, the elimination of oil and other foreign matter from the feed water is entirely within the attendant's province and should not be too large a problem for him. As for restricted steam area, insufficient water area, etc., these cannot be remedied except by a radical change in equipment, which probably would mean laying out considerable money. It is not often, however, that a boiler of reputable make has such defects.

Usually in a boiler that tends to prime, the first remedy is to install a dry-pipe, plate or box, if the boiler is not already so equipped. It should be remembered, however, that such a remedy does not remove the cause, but only the effect, and that it is not always positive in doing this. While all boilers, as a rule, should no doubt be so equipped, yet the matter should hardly be allowed to rest there.

One-Sided Development

The failure of many a man in business is explained by the statement, "he lacks business tact and ability."

This same statement would explain the failure, or partial failure, of many a man in a professional line. The reason is that most men who acquire a high degree of knowledge of a scientific or cultural subject do not have left sufficient time and energy to develop business ability. For in these days business is almost a science by itself, and the ability to transact it is an acquired, or at least a cultivated ability by most men who have it.

The fact that men must forego cultivating this faculty while they devote their entire time and energy to cultivating a faculty along professional lines, explains the practice of so many professional people of having managers to conduct the business of marketing their services.

This arrangement among professional people has its lessons for the engineer. The competent, efficient power-plant engineer must have, today, enough "book knowledge" to entitle him to a place in professional ranks. In order to acquire this knowledge he devotes all his spare time and energy to study and experiment along the one line—engineering—to the exclusion of thought and culture along other lines, including the art of conducting business.

No wonder then that he is underpaid, which means simply that he has not, as a rule, acquired the business ability needed to sell his own services at a price which represents their real value.

But what shall he do about it? This is the practical question that arises. Engineers cannot employ business managers as do actors and musicians, or perhaps not even business brokers, as do some inventors, to market their services or product It seems certain, however, that some way could be devised to improve matters. Do engineers feel the need of doing something to improve conditions in this respect? Are they disposed to coöperate in some effort in this direction? Let us hear from men who approve the idea of making an effort, and especially from men who have any ideas about a plan.

Not all the letters that come in can be published, of course, but the first with each really new and worthy idea will be and all will be carefully considered and the composite of their ideas ultimately submitted to our readers in some form.

Engine Ratings

We find that to the layman the usual practice in rating steam engines often leads to confusion. In attempting to set our correspondents straight on this point we are often led to question whether there is any real significance to an engine rating.

If one were to attempt to settle this point by searching through engine catalogs, he would find that the majority, while specifying certain steam consumptions for full and fractional loads, nevertheless, do not commit themselves to any definite ratings for different engine sizes. This omission is undoubtedly for the purpose of permitting flexibility to suit individual conditions.

It is true that on a tentative basis most builders rate their engines at a load corresponding to about one-quarter cutoff, but this merely signifies the most economical point without reference to the maximum load the engine will carry. Moreover, engines of the same size, but of different makes, are seldom rated the same, a fact explained by the designers using different mean effective pressures.

Again, operating conditions in the average steam plant have also greatly influenced engine ratings. If the majority of plants were to operate continuously at their maximum load and the demands for exhaust steam were such as to make steam consumption a matter of secondary importance, then it might be reasonable to rate the engines at their maximum load. But as conditions actually exist, in most plants the maximum load comes on only for short periods and the engine runs for a greater part of the time at from one-half to two-thirds this maximum load; that is at a load approaching the most economical point of cutoff—if the proper-sized engine is installed.

New Jersey Engineers, Attention!

We call the attention of engineers and firemen of New Jersey to the fact that their applications for licenses must be in the hands of the Secretary of Labor, Trenton, N. J., on or before Sept. 4, to entitle them to licenses without undergoing examination. This is a privilege that all now employed as engineers and firemen should take advantage of and not lose by neglect. Firemen should realize they too must procure a license; many of them seem to think the law relates to engineers only.

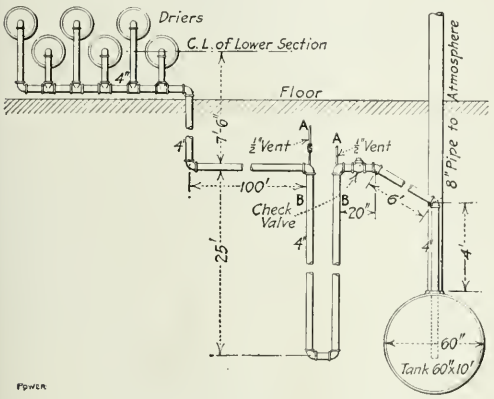
The law requires that certain information must be forwarded to the Secretary of Labor when application for license is made. On page 280 of this issue a form of application blank stating what information is needed is given. This form was prepared by A. L. Case, chairman of the License Law Committee of the N. A. S. E., for the convenience of members.

Owing to lack of funds due to failure of the legislature to make an appropriation, the bureau of examiners, the creation of which the law authorizes, will not be organized this season.

READERS WITH SOMETHING TO SAY

Air-Bound Water Seal

In a paper mill where I am employed a peculiar thing happened recently, that has remained somewhat of a puzzle ever since. There are four paper machines that discharge condensation from the driers into a receiving tank, into which also empties the condensation from the heating system. A centrifugal pump forces the water from the tank to the boiler room.



SEAL IN RETURN PIPE FROM DRYERS

When the machines were installed there was no trap, water seal or anything placed on the discharge line from the driers, consequently considerable steam passed through the driers and did not become condensed. Recently a water-seal was placed on the discharge line as shown in the sketch. One-half-inch vent pipes *AA* were placed on top of each leg *BB* of the seal. The one on the machine side had a valve while the other was at first a short piece of pipe about 10 in. long. During the first week after installing the seal, the rush of water at times was great enough to force water out at the top of this vent. This was objectionable, as employees passing below were in danger of being scalded. I therefore drove a wooden plug in this pipe, intending to have the pipe extended higher the following Sunday. This was forgotten and about 3 p.m. Monday the driers became full of water. On opening the valve on the one vent and removing the plug from the other, air issued for about ten seconds from both vents, and then a rush of hot water followed. In about five minutes the driers were empty and everything working in good order.

The line was surely air-bound, but the puzzle is how could they have become so bound? A pressure in the driers of 5 to 10 lb. and a head of 7½ ft. from the driers to the top of the seal would surely be sufficient to force air into the tank, in which no pressure above the atmosphere could exist. It seems impossible that air could gather and remain in the top of the seal next to the tank sufficiently to choke the water back, for it would be necessary to confine it on all sides, and next to the tank there is no pressure to do this. It seems possible that air enough might gather in the machine side of the loop to reduce the flow of water, as it (the body of air) would be subjected to pressure on all sides. But if that is true, why does it not occur again as the valve in the vent pipe is closed all the time. The one on the other side is open all the time, but how could it affect the other side of the seal? There must have been some water passing into the tank, else the driers would sooner have become filled. The tank is provided with an overflow and was in good condition at the time, so it was not filled with water above normal.

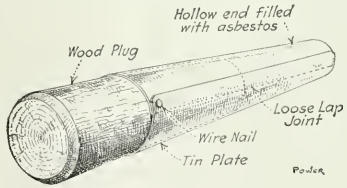
If air on the tank side restricted the flow of water, how is it to be accounted for? If it was air on the machine side that did it why does it not happen again? If the check valve was stuck, or failed to lift enough, why would opening the vent pipes remedy it? The writer will be pleased to have this explained.

JOSEPH STEWART.

Hamilton, Ohio.

Plugs for Hollow Stays on Heine Boilers

Some time ago the writer was associated with the operation of a power plant where Heine boilers were installed. As those familiar with this type of boiler are aware, the front and rear headers have openings let through them for the purpose of blowing off the tubes, these openings being in the form of hollow stays which are beaded over at each end. At first, when the number of boilers was small, tapered wooden plugs were used to close these openings as it was found that through the expansion and contraction almost any type of metal plug would soon loosen and fall out of place.



PLUG FOR HEINE BOILER

The wooden plugs were far from satisfactory because their inner ends, being exposed to the heat of the furnace, would burn off, necessitating renewal of the plugs after about ten days' use. With only a few boilers in use this was not a serious consideration, but as the plant grew and more boilers were added, it became necessary to employ a large proportion of a man's time turning new plugs.

After various expedients had been tried and discarded, the writer suggested a form of plug, which was experi-

mented with and found satisfactory. This was a taper plug made in the manner shown in the sketch. To construct a sample for trial, one of the old plugs was turned down in a lathe an amount equal to the thickness of a sheet of tin. The small end was cut off about 1½ in. back and had tin plate wrapped around the stub, overlapped and nailed. The small end of the tin plate being free at the joint will spring open and shut, the tin sliding over itself at the lap. Then the opening formed by the extension of the tin beyond the wood was filled with asbestos to protect the wood stub, and rammed tight, the reduced size of the chamber at the open end holding the asbestos in place. When these plugs are tightly inserted in the holes the free ends of the tin tubes are slightly compressed and the spring of the tin plate takes up all difference of expansion.

These plugs cost about three times as much as the plain wooden ones, but some that were examined after six months' use appeared to be as good as new, with prospects of lasting indefinitely.

Otto E. Trautmann.

New York City.

Had No Success with Graphite

The Esterville (Iowa) Light, Power & Water Co.'s plant of which I have charge has horizontal tubular boilers. Each gallon of feed water contains: 27 gr. sulphate of lime, 5 gr. carbonate of lime, 12 gr. carbonate magnesium, 2 gr. sodium potassium sulphate, 1 gr. sodium potassium chlorides.

Many different boiler compounds have been used, also kerosene in large quantities, but these boilers have been heavily scaled since their installation.

About two years ago I began feeding caustic soda and soda ash and in six months the boilers were free from scale. The fire sheets threw off the scale much more rapidly than the flues. Of course, we were troubled from foaming, packing troubles and lubrication troubles due to the action of the caustic soda, but we always managed to work the boilers to full capacity and considerable overload. Wishing to overcome these last-named troubles I decided to try graphite.

We got a 100-lb. keg of boiler graphite of a well known make, read the directions and started using it by doubling the dose recommended. The fire sheets were absolutely clean and the flues were practically free from scale when we began using the graphite.

Two weeks after using the graphite I washed the boilers and found a coating of hard, white scale about the thickness of an egg shell over the fire sheets. We continued the use of graphite until 100 lb. were used and then started on another 100-lb. keg of graphite.

Each two weeks' run showed a corresponding increase in the thickness of the hard, white scale until the second keg of graphite was used. The flues seemed to hold their own, neither throwing off any old scale or accumulating any new. But the fire sheets had rapidly taken on new scale. What better test could be given the graphite than these clean sheets to start on?

We went back to caustic-soda treatment and the new scale was all off again in about two months. I wrote the makers of the graphite, giving them the same explanation that I have given here, and in their reply they simply said that if I used the graphite according to their instructions there was not a case of boiler scale that would not yield to the graphite treatment. I was very anxious to make it a success as it would have been a boon to our steam plant had it been a success.

The first boiler inspector's report in 18 years to read "boilers free from scale" came to this plant recently because of the use of caustic soda and soda ash. We use 1 lb. soda ash and ⅛ lb. caustic soda to 600 gal. feed water.

E. C. Sutton.

Esterville, Iowa.

[The manufacturers of boiler graphite up to the present, have not made broadly the claim that graphite would prevent the formation of scale. The product is recommended chiefly as a scale remover. It is probable that if Mr. Sutton had emptied his boilers and coated the shell with graphite while the plates were free from scale, no scale would have formed. Some engineers coat the boiler with graphite and also use soda ash.—Editor.]

Iron in Receiver Goes to Engine

In this plant one of our 60-hp. cross-compound Corliss engines suddenly developed a loud knock. On shuting down the engine, we found that the piston rod on the low-pressure side was bent. The piston head was taken off and all the follower bolts were found in place. The valves were taken out and found in good condition. The piston was then removed. On the crank-end cylinder head and on the spider were found impressions like the picture of a bird with its wing outspread. A piece of iron in this shape was found, which had dropped through the valve into the exhaust chamber.

Next the receiver was opened and a bucketful of iron clamps and pieces of packing rings was taken from the bottom. The clamps had fallen off the heating coils.

One of the these clamps was picked up by the steam and blown through the low-pressure cylinder, being caught between the piston and head, and the clamp then fell through the lower valve. Strange to say, it passed through both the valves without injuring them.

T. F. White.

Handley, Tex.

Test for Pressure Drop in Long Steam Pipe

A test for pressure and temperature drop on a 5-in. steam line 1700 ft. long, having thirteen 90-deg. elbows and covered with the best grade of pipe covering, showed a pressure of 155 lb. at the boilers, with a steam temperature of 470 deg., 102 deg. superheat. At the end of the line a pressure of 150 lb. was obtained, with a temperature of 365 deg. and practically dry steam.

This line supplies steam for operating a 50-ton ice machine, a three-cylinder compound pumping engine, 13, 16, 13⅞ and 18 in.; one 7½- and 4½x10-in. pilot-pressure pump and eight vacuum pumps of various sizes. Steam is supplied to this line by a 500-hp. water-tube boiler.

During the 24-hr. test, while the steam was carried at 155 lb., the superheat ranged from 89 to 102 deg., according to the load on the boilers.

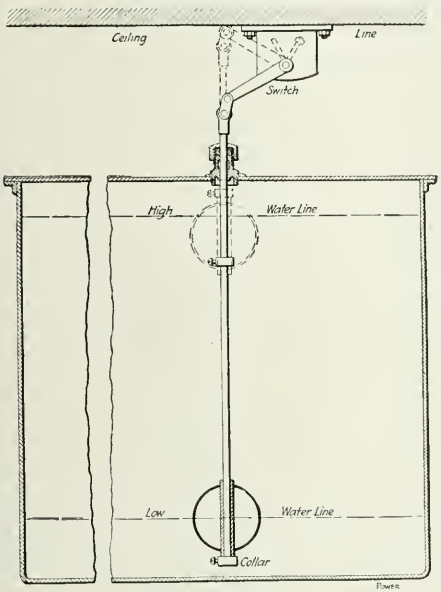
F. J. Raylin.

Chicago, Ill.

QUESTIONS BEFORE THE HOUSE

Float Switch for Tank with Little Headroom

The automatic pump control shown by H. B. McDermid in the July 1 issue brings to my mind an automatic pump control which I made and installed on a tank of heavy boiler iron measuring 24x48x72 in., and which served as a receiver or drip tank, to which all the trap discharges in various parts of the factory were returned,



HOME-MADE TANK SWITCH

being then pumped from this tank by an electrically driven triplex pump to the main storage tank for hot water located in the heater room.

As this tank was placed in the basement of the boiler room the height of which was about 6½ ft. from the ceiling to the floor, there was very little head room between the tank and ceiling. It was desired to have the pump draw the water to within 6 in. from the bottom, also to allow the tank to nearly fill before starting the pump.

The available headroom between the top of the tank and the ceiling was about 18 in. and as it was desired to have the tank steam tight, the chain and float with counterweight could not be used as steam would leak around the chain where it passes through the top of the tank. It was decided that a rod could not be used because it would have to have a movement of nearly 40 in.

Taking a heavy 8 in. copper float I drilled a hole through its axis large enough to fit a ½-in. pipe. This pipe was cut off within ¼ in. of each end of the float and soldered water tight. With a suitable stuffing-box obtained from an old globe valve and with a rod of proper size and length, I placed the float on the rod and adjusted the collars to the height of water I wished to carry. The tank switch, which is of the spring-trip quick-release single-pole type, is mounted on the ceiling directly above the tank, and the rod, with suitable link connection as shown in the sketch, was connected to the operating lever of the switch. This switch merely opens and closes the motor circuit by opening and closing the circuit breaker. The pump is a triplex, single-acting pump of 120 gal. per min. capacity and pumps the tank dry in five to six minutes. This outfit is looked after about once a week and has given no trouble since it was put in about 3 months ago.

Comment on Peculiar Diagrams

Replying to John T. Sharp, Jr., in the June 17 issue, as to the unusual indicator diagrams, I wish to say that the engine from which these diagrams were taken is evidently running light, as the cutoff should be 25 per cent. for good working loads. The lower diagram is all right for the load, the other shows too early compression, too late and too slow release. I think if these were remedied, the cutoff would take care of itself. When the latter two conditions are fixed, there should be no loop and there would be a horizontal exhaust line.

S. T. BLAKEMAN.

Senatobia, Miss.

Air-Driven Pump Freezes

In reply to the question of H. E. Leonard on page 138, July 22 issue, I operated an air-driven pump in a coal mine using air at 70 lb. pressure. The pump was 1000 ft. from the compressor, and I experienced the same trouble he speaks of. During the warm weather ice would form on the end of the exhaust pipe that I would knock off with a hammer, but in cold weather ice would form under the slide valve and would obstruct the exhaust. When the pump commenced to slow down I would stop it and let it stand about five minutes. That would let the temperature rise; then when I started it again the ice would break loose from the valve and blow out. This operation was repeated whenever it was required.

The proper way to remedy this trouble is to put a ⅛-in. pipe inside the exhaust pipe and bring it out through the exhaust pipe and connect it to the discharge pipe of the pump. The ends of the ⅛-in. pipe should be flattened a little so as to make a spray.

F. M. BENJAMIN.

St. Cloud, Fla.

[More good discussion of means to prevent the freezing of air-driven pumps would be welcomed.—EDITOR.]

INQUIRIES OF GENERAL INTEREST

Electrical Capacity Measurement—In what units is the capacity of an electrical condenser measured?

B. M.

The unit of capacity is the farad, which is defined as the capacity of a condenser which requires one ampere per second to raise its potential from zero to 1 volt.

Safe Boiler Pressure—What steam pressure is allowable on a water-tube boiler and what on a fire-tube boiler?

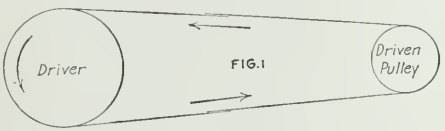
J. C. M.

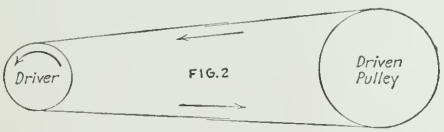
The pressure allowable for any boiler depends on its design, material of construction, workmanship and condition. Water-tube boilers are generally made to carry 150 to 200 lb., while present fire-tube boilers are generally made to carry 100 to 150 lb. However, the pressure allowable for a boiler of either class depends, in any case, on the pressure assumed to be safe after inspection, computation of strength and application of a hydraulic test pressure.

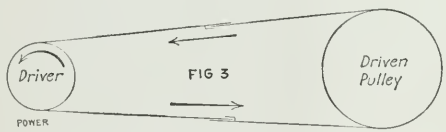
Belt Splice—How should a cemented belt joint be lapped and which direction should the belt run?

E. H. B.

A belt with a cemented lap joint should be driven in such a direction that the lap next to the pulley will be wiped down by the pulley on which the belt is more likely to slip. Therefore, if the driving pulley is larger, or of the same diameter as the driven pulley, then, as slipping is more likely







to occur by the belt being dragged over the driven pulley, the butt end of the flap should travel forward, as shown in Fig. 1. If the driving pulley is smaller than the driven pulley, then slipping being more likely to occur by the driving pulley slipping ahead of the belt, the belt should be put on so the thin end of the flap travels forward, as indicated in Fig. 2. A graft lap, like Fig. 3, should be used when conditions require the main lap to travel in the direction shown in Fig. 2, but no graft lap is necessary when conditions require the main lap to travel as shown in Fig. 1.

Pipe-Fitting Friction—In its resistance to steam flow, how would the friction in a 90-deg., 7-in.- elbow compare with that in straight pipe?

W. W. C.

It would be equivalent to the resistance in passing through about 520 diameters of pipe of the same size, i.e., a 90-deg. elbow in a 7-in. steam line offers the same resistance to flow as passage through

$$\frac{520 \times 7}{12} = 303\tfrac{1}{3} \text{ ft. of 7-in. pipe.}$$

Engine Economy—We have a noncondensing Corliss engine supplied with steam at 80-lb. pressure and cutting off at 1/2-stroke. About how much could be saved by installing a new boiler and carry 100 lb.?

J. N.

With 80-lb. boiler pressure and cutoff at 1/2-stroke, the terminal pressure would be down very close to atmospheric pressure. At 100-lb. initial pressure, cutoff, with the same load, would be so short as to cause expansion below the atmosphere, thereby causing cylinder cooling by drawing in air during the first part of the return stroke. Under such circumstances 100-lb. initial pressure would not be as economical as the present 80-lb. If a diagram taken with average load shows no more than about 3-lb. terminal pressure, then it certainly would not be more economical to install a new boiler and use 100-lb. initial pressure.

Mean Effective Pressure—How is the mean effective pressure found without an indicator?

C. E. M.

It can be estimated from knowledge of the initial pressure, point of cutoff and average back pressure by the formula

$$P_m = (1 + \log_e R)\ (f + c) - c,$$

in which

P_m = Mean forward pressure per pound of initial pressure;
$\log_e R$ = Logarithm of the ratio of expansion;
f = Per cent. of cutoff;
c = Per cent. of clearance.

From this mean forward pressure the mean back pressure (both absolute) is subtracted, leaving the mean effective pressure. Instead of making the computation, the mean forward pressure is usually taken from tables such as those in Low's "Steam Engine Indicator," pages 115 and 116.

Connecting Waterwheel and Engine—Is it advisable to connect a waterwheel having no governor and an engine so as to obtain their combined power on a single shaft? How should it be done?

I. C.

It would be feasible to connect the engine with the waterwheel, with a governor only on the engine, if the power is always in excess of the amount developed by the waterwheel and the engine and waterwheel are coupled together so that each runs at its proper speed. Care should be taken that the engine is started first, or that it is thoroughly warmed up before the waterwheel is started, as a head might be knocked out if there was water in the cylinder of the engine. It is safest to have a clutch coupling between the powers and after starting the waterwheel slowly to start the engine slowly with the drip cocks open and bring the speed up gradually on both the engine and the waterwheel before throwing in the clutch coupling.

Corliss and Slide-Valve Engine Cutoffs—Why is it that a Corliss valve gear with one wristplate cannot cutoff between near one-half stroke and a point very near the end of the stroke? Why, with a plain slide valve, is it impracticable to cutoff before one-half stroke?

E. H. I.

A Corliss valve gear with one wristplate has to open and close the exhaust valves of the engine by a reciprocating motion during one-half of a revolution of the engine; i.e., during the return stroke of the piston, as the exhaust-valve connections with the wristplate are positive in their action. The cam-cutoff mechanism of the steam valves is operative in only one direction and, as the wristplate for operating the exhaust valves has to be reversed when one-half of the stroke is completed, the cutoff cams cannot control cutoff through a greater range than one-half stroke.

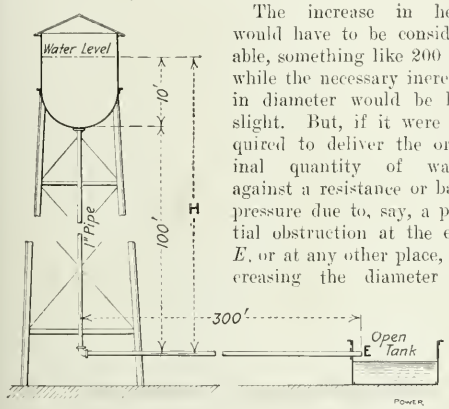
To effect cutoff with an ordinary slide-valve engine it is necessary to advance the eccentric, thereby simultaneously advancing the time of admission, release and closing of the exhaust. By adding lap to the steam ends of the valve, undue lead can be prevented, and early opening of the exhaust also can be prevented by adding inside lap (i.e., on the exhaust edges of the valve). But if these operations are carried so far as to be adapted to cutoff at less than about five-eighths stroke, early release and back pressure are increased so much as to reduce power and economy below practical requirements.

ENGINEERS' STUDY COURSE

Chimney Design

When water is conveyed in a pipe the quantity delivered per unit of time depends upon the diameter and length of the pipe, the friction due to the nature of the pipe surface and the kind and number of the turns in the pipe, the difference between the pressure or head at the starting point and at the delivery point.

For illustration, consider a 1-in. pipe line, 400 ft. long, arranged as shown in Fig. 1. Assume that under the conditions shown, 9 gal. of water is delivered per minute and that it is desired to increase the quantity to, say, 12 gal. per min. As the nature of the pipe surface and the number of turns cannot be changed, it will be necessary to increase the head *H* or increase the diameter of the pipe to secure the desired result.



Illustrating Head Friction and Flow

The increase in head would have to be considerable, something like 200 ft., while the necessary increase in diameter would be but slight. But, if it were required to deliver the original quantity of water against a resistance or back pressure due to, say, a partial obstruction at the end *E*, or at any other place, increasing the diameter of the pipe would be of but slight use. The only benefit derived would be a certain reduction in the friction of the pipe itself, which would leave just that much more pressure available at *E* for overcoming the resistance there, resulting in a somewhat increased flow.

On the other hand, any increase in head *H*, produced by raising the upper tank, would almost all be available for overcoming the local resistance or back pressure at *E*, the only amount lost being due to the slight additional friction of the required additional length of vertical pipe.

The principles of boiler-furnace draft, produced by a chimney, are very similar to those involved in the foregoing illustration. One difference in actual application is that the chimney system seemingly works upside down. The boiler room itself corresponds to the overhead tank in Fig. 1; the furnace, gas passages of the boiler, breeching and chimney are the piping system. But, instead of the flow being downward, as in the case of the water system, it is upward. Nevertheless, gravity is the actuating force in both cases. The heavy cool air outside the chimney containing the light, hot gases has, due to the force of gravity, a continual tendency to seek its own levels in the chimney and force up the light gases. It never succeeds, however, for as long as the fire is maintained the heavy cool air is converted into light hot gas in passing through the fuel bed.

The important point of comparison between the water system here illustrated and a natural-draft system is that similar changes in dimensions or design produce similar results. If it is desired to increase the head (or draft) so that a certain rate of flow may be maintained against a given resistance, logically, the height of the water pipe or chimney, as the case may be, must be increased. While increasing the area of the piping or the gas passages helps to a slight extent, the main resistance (at *E*, Fig. 1, or at the fuel bed in the case of a draft problem) is usually so large that only a change in height will suffice. In other words, the head or draft, or tendency to flow—whichever you call it—must be great enough so that the resistance or friction will be overcome and there will still remain a certain amount of draft to produce a flow or velocity sufficient to handle the required quantity of gas per unit of time.

When this condition has been fulfilled the size of breeching and diameter of chimney must be determined. Here, just as with the water piping, the area of the passages is the factor which has the greatest effect on the capacity (volume of gas handled per unit of time). And it is poor economy to add to the height simply to increase the capacity by making the velocity abnormally high.

Estimating Draft Required

Before we are in a position to design a suitable chimney for a given plant we must have some data as to the draft that will be required under the working conditions. Knowing this, we can then determine the necessary height. To estimate the draft that will be required we must know the approximate nature of the fuel to be burned, the rate at which the fuel is to be burned, the grate area, the type of boiler to be used, manner of baffling, length of the breeching, its cross-sectional area and the number of turns it makes. In fact, we should know, if possible, all the factors that affect the draft and the amount of their influence.

Unfortunately, it is almost impossible to permanently determine all the factors. After a plant has been running a year or so, it may be necessary to change the grade of coal used. Or, it may be necessary to add more boilers than were originally provided for or to greatly overload the existing plant. All these changes would have their effect on the draft requirements. Hence, as the load on the stack is usually increased and but seldom diminished, it is a good and safe mistake to make the chimney too large rather than too small. The intelligent engineer will offset too much stack capacity by a careful use of the dampers, but he is helpless if he is afflicted with a heavily overloaded chimney.

The study of draft losses in a boiler installation is such a broad one and so many factors enter into the

problems involved that it is impossible to do more than briefly outline the details here.

In calculating the draft required for a given installation allow 0.001 in. of water for each foot in the length of the breeching, measured from the chimney to the nearest boiler; 0.05 in. for each right-angle turn in the breeching, and 0.4 in. for the boiler or boilers themselves.

These figures are based on average conditions and they are safe for use with most of the ordinary installations where the cross-sectional area of the breeching is 20 per cent. greater than the smallest free cross-sectional area of the chimney and where the boiler is of any standard design and has the usual baffle and gas-passage arrangements.

After having allowed a certain quantity of draft for overcoming the resistance of the boilers and gas passages it is next necessary to estimate the draft required at the fuel bed. This factor depends on the kind and size of the fuel to be burned and the rate of combustion required to carry the load on the boiler.

To estimate the rate of combustion it is necessary to take into consideration the maximum horsepower to be developed; the pounds of coal required to develop one horsepower-hour, and the area of the grate. Multiplying the first two factors together and dividing by the last gives the rate of combustion in pounds per square foot of grate per hour. When this quantity has been estimated the approximate draft required may be obtained from Table 1, compiled from some data given in "Stirling" and some furnished by the Green Engineering Co.

TABLE I. DRAFT REQUIRED IN INCHES OF WATER FOR VARIOUS COALS AND RATES OF COMBUSTION

Kind of Coal	Pounds of Coal Burned per Sq.Ft. of Grate per Hr.								
	10	15	20	25	30	35	40	45	50
Run-of-mine—bituminous	0.07	0.12	0.18	0.23	0.30	0.37	0.45	0.52	0.60
Bituminous slack	0.09	0.14	0.23	0.30	0.40	0.48	0.57	0.65	0.75
Run-of-mine—semi-bituminous	0.07	0.14	0.23	0.32	0.45	0.60	0.77	0.95	1.20
Semi-bituminous slack	0	0.10	0.16	0.28	0.40	0.57	0.73	0.90	1.10 1.37
Anthracite pea	0	0.16	0.30	0.45	0.64	0.88	1.25		
Anthracite No. 1 buckwheat	0	0.23	0.43	0.68	1.00	1.40			
Anthracite No. 3 buckwheat	0	0.39	0.75	1.25	2.00				

To illustrate, assume that it is desired to find the draft required by an installation of four 400-hp. boilers, the maximum load on which is to be 2000 hp.; the fuel is to be a fair grade of semi-bituminous mine run, 3½ lb. of which are sufficient to develop one boiler horsepower under fair, average conditions; the area of the grate under each boiler is 88 sq.ft. The breeching is 30 ft. long and has one right-angle turn.

The draft loss for the breeching will be

$$(30 \times 0.001) + 0.05 = 0.08 \text{ in. of water}$$

and assuming 0.4 in. for the boilers themselves, the total draft loss from furnace to stack will be

$$0.4 + 0.08 = 0.48 \text{ in.}$$

As 2000 hp. are to be developed requiring the combustion of 3½ lb. of coal per boiler horsepower per hour, the total coal to be burned per hour equals

$$2000 \times 3.5 = 7000 \text{ lb.}$$

As the total grate area is

$$4 \times 88 = 352 \text{ sq.ft.},$$

the pounds of coal burned per square foot of grate per hour will be

$$\frac{7000}{352} = 19.9$$

By referring to Table 1 it will be found that 0.23 in. of draft is required for the combustion of run-of-mine semi-bituminous coal at a rate of approximately 20 lb. per sq.ft. of grate per hour. Then, adding this quantity to the quantity estimated to be required to overcome the resistance of the boiler and breeching, we have a total draft requirement of

$$0.48 + 0.23 = 0.71 \text{ in. of water.}$$

The next step is to estimate the height of chimney required to develop this amount or intensity of draft.

Height of Chimney

In a previous lecture a formula was given for estimating the amount of draft to be expected of a chimney of a given height under certain conditions. By rearranging and modifying this formula slightly it will serve for estimating the height of chimney required when the draft is known. The original form (see issue of Aug. 12) was

$$D = 0.52\ H \times P\left(\frac{1}{T} - \frac{1}{T'}\right)$$

By transposing the factor H to the left side of the equation the formula takes a more convenient form for its present application, thus,

$$H = \frac{D}{0.52\ P\left(\frac{1}{T} - \frac{1}{T'}\right)}$$

where D represents the draft required and all the other symbols are the same as in the previous case.

Now, the chimney itself offers some resistance to the flow of the gases and allowance should be made for this. A common estimate of this loss is 20 per cent. of the total draft developed. That is, if a perfectly frictionless imaginary chimney could develop, say, 1.25 in. of draft in actual practice a chimney of the same size would develop only 80 per cent. of this figure, or 1 in., the other 20 per cent. being lost in overcoming the friction that every actual chimney possesses.

Hence, in applying the foregoing formula we should first increase by 25 per cent. the figure representing the draft required, so as to obtain a chimney of such height that 20 per cent. of the estimated draft may be lost and still leave the required amount. Or, better still, we can change the formula to take care of this by multiplying the draft required by the factor 1.25, making the formula read thus:

$$H = \frac{1.25\ D}{0.52\ P\left(\frac{1}{T} - \frac{1}{T'}\right)}$$

In applying this formula to the draft problem just illustrated, we must first ascertain what the average atmospheric pressure (P) is at the location of the plant. At or near sea level, this pressure may be taken as 14.7 lb. per sq.in., but where the altitude is considerable, as for instance, at Denver, which is at an elevation of over 5,000 ft. above the sea, a closer figure should be taken. At Denver, 12.5 lb. per sq.in. would be proper.

We must also ascertain what the average atmospheric temperature is at the place where the plant is located and estimate what the temperature of the flue gases probably will be. The last-mentioned factor will depend upon the design of the boiler, arrangement of baffles, cleanliness of the heat-absorbing surfaces, rate of combustion, and, somewhat, upon the efficiency of combustion. On an average the flue-gas temperature ranges between 450 and 600 deg.

In our present example, assume that the atmospheric pressure is 14.7 lb. per sq.in., the atmospheric temperature is 70 deg. F., and the temperature of the flue gases 500 deg. F. The corresponding absolute temperatures are 530 and 960 deg., respectively.

Substituting in the formula, then, we find the height of chimney required to develop an available draft of 0.71 in. is

$$H = \frac{1.25 \times 0.71}{0.52 \times 14.7 \left(\frac{1}{530} - \frac{1}{960}\right)} = \frac{0.8875}{7.644 \left(\frac{430}{508,800}\right)}$$

$$= 137.38 \text{ ft.}$$

or, in round numbers, 140 ft. above the grates.

Diameter of Chimney

Having determined the proper height of chimney for a given set of conditions it is next necessary to estimate the required free cross-sectional area. For this the following formula may be used:

$$E = \frac{F}{16.65 \sqrt{H}}$$

where

E = Cross-sectional area of the chimney in square feet;
F = Pounds of fuel to be burned per hour;
H = Height of chimney above the grates in feet.

Applying this formula to our example, we have

$$E = \frac{7000}{16.65 \sqrt{140}} = \frac{7000}{16.65 \times 11.83} = 35.5 \text{ sq.ft.}$$

The diameter of a chimney of this area would be about 6 ft. 9 in.

Chimneys are usually built circular because this form is cheaper, more stable and more efficient than any other. It is cheaper because less material is required for a chimney of a given cross-sectional area; more stable because the curved surface of a round chimney offers less resistance to the wind than the flat surface of a square or other polygonal (many-sided) chimney; also, because structurally the circular section is stronger. A circular chimney is more efficient because the resistance to the flow of the gases is less per unit of sectional area and the amount of exposed surface is less than with any other shape due to the fact that the circumference of a circle is shorter than the perimeter of a square or polygon.

Practice Problem

By way of exercise, those who are interested may work out the dimensions of a chimney for the following conditions: Eight 500-hp. boilers, with grates 83 sq.ft. in area, to be fired with bituminous slack, the combustion of 4 lb. of which is required per boiler horsepower-hour. At times the boilers will be overloaded 25 per cent. The breeching is 50 ft. long from the chimney to the nearest boiler and has two right-angle turns in it. The plant is located about 2000 ft. above sea level, where the average atmospheric pressure is 13.57 lb. per sq. in. The temperature of the outside air will average 60 deg. F. and that of the flue gases 550.

⁂

Superheaters are to be applied to all the locomotives on the New York, New Haven & Hartford R.R. The estimated expenditure is nearly $1,000,000, and the locomotives will be equipped at the rate of five per month. The work will be done at the Readville, Mass., shop, and about 350 locomotives in all will be altered.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Concluding that a hermetically sealed package contained a liquid explosive, a weisenheimer put the package in a pail of water. We'd like to know just what action water has on a hermetically sealed package.

⁂

Editor the Spillway:

In a recent issue there's an article, "Heating Engineers Meet at Buffalo." This makes me not. Why single out Buffalo engineers when they are heating engineers' meat in every city in the U. S.?

Chicago, Ill. R. C. SMITH.

Look'y here, Mister Smith, you're trying to kid us. It's all very well to heat the meat if you don't have to meet the heat—of a Chicago summer. Anyhow, buffalo meat is a luxury these high-living days, and once a year is none too often.

⁂

Secretary Daniels of the Navy would give every enlisted sailor a chance to learn a trade; "make Jack a useful citizen when he retires." The same thing is advised for Tommy in the Army. When Henry, in the power plant retires— Oh, well, we had a suggestion for Henry, but he dont retire so's you can notice it; he has to keep on going.

⁂

The new steamer "Tyler," remarks the "New York Times," has "one triple-expansion engine, with cylinders 19¾, 33¼, 58 in. diameter by 42-ft. stroke." Some stroke!

⁂

A Western farmer has an artesian well from which he gets sufficient power to electrically light his house and barns and operate some small machinery. In most of those wells we call artesian in the East the water has to be coaxed up to the surface, and the internal force wouldn't light a match.

⁂

Ever smoke an Igorot cigar? Well, these Igorots, in the Philippine Islands, make a cigar that in one respect is like the old-time Christmas plum pudding—it lasts a week. It's 15 in. long and 3 to 5 in. thick. Old man Ig. rolls the cig. and smokes it an hour; then Missis Ig. and all the little Igs. take their turns. By about the fourth day it must need a cuspidor attachment to keep it in operation. One smoke like this would last some people a lifetime.

⁂

COME WITH US, ALEXANDER!

Are you going to the Springfield N. A. S. E. convention on Sept. 8? This question should be agitating your mind, Alec, this present moment.

If you can't go, that lets you out right here and now. If you are just doggone indifferent or haven't made up your mind either way, you listen to your Uncle Bill!

You've probably stuck around the plant 325 days this year; you've gone stale, and peeved, and grouchy. The kids get on your nerves when you come home nights; the insurance premiums are pestering you: your grocer is sure cheating you ont of your eye-teeth: the butcher is buying a new buz wagon on your money—mebbe the washlady has a new bicycle because she put a few over on you, or—

Say, Alec, you go easy with the whip, this is a hired rig. All you need is a rest-up and a ride in the cars to Springfield. Come across with yourself. When, at the supper table tonight, you've finished your second helping of corned beef and cabbage, you up and tell your Ethel—

"Old girl, you corral a few of your best duds, lay out my funeral pants, my Sunday shirt and those blue silk socks, dig up a couple of suitcases. You and I are going to the convention! N-e-v-e-r m-i-n-d, now! Aunt Hannah will come over and mind the kids. You-and-I-are-going-to-Springfield. Get me, Ethel?"

Then, for the loveofmike, stick! If you can't see your way to stop at the Walledoff-Castoria, go stop with grandma Spriggins—or even with Ethel's mother. But go!

Honest, Alec, you can't count in dollars and cents the good it will do you—and Ethel. Aunt Hannah may not be any too tickled, but the kids will be glad to get rid of you. And they'll love you all the more on your return with a sunny smile instead of the old grouch.

Come with us, old man. It's all aboard for Springfield, and everybody's doing it. You do it—now!

Application for New Jersey License

The time in which the engineers and firemen of New Jersey have to make application for a license without being examined is growing very short, for to enjoy this privilege, one's application must be in the hands of the Secretary of Labor, Trenton, N. J., on or before Sept. 4.

The accompanying application blank shows the information which the law states must be forwarded to the Secretary of Labor when making application for license.

The form was drawn up and prepared by A. L. Case, chairman of the New Jersey License Law Committee of

Form D-1-13

STATE OF NEW JERSEY **APPLICATION NO.** DEPARTMENT OF LABOR

BUREAU OF ENGINEERS AND BOILER OPPERATORS LICENSE

APPLICATION FOR LICENSE

N J 191

Name

Post Office { Street and Number / City or Town } County

Age Color Nationality Citizen

Experience as Stationary Engineer Years Months

Experience as Locomotive Engineer Years Months

Experience as Portable Engineer Years Months

Experience as Hoisting Engineer Years Months

Experience as Marine Engineer Years Months

Experience as Oiler in Engine Room Years Months

Experience as Boiler Operator Years Months

Experience as Locomotive Fireman Years Months

Experience with Steam Heating Plants Years Months

What kind of a boiler, or boilers have you in charge of at the present time?

What is the Horse Power?

Do you supply water to your boiler with a pump or injector?

What kind of engines are you now running?

What is the Horse Power?

Do you operate electrical Machinery?

If so, for what purpose?

If you use steam for heating purposes, by what system?

Do you use condensers? If so what type?

Is firing done by hand, or with stokers?

Do you have mechanical ventilation? System.

Do you operate elevators? Name of Manufacturer...

Do you operate refrigeration? For what purpose

By what system? Absorption or direct expansion?

What is the name and address of firm by whom you are now employed?

For what is the plant used that you desire to operate?

Have you ever applied to any District Examiner in New Jersey for an examination?

If so, did you secure a license?

Who was the District Examiner?

What was the date of your LAST examination?

Do you now hold a license? If so give No.

When does your license expire?

Applicant's Signature

The applicant whose signature appears above is employed as engineer at... and who request that a proper license be issued to him

Signed

Title

Address

the N. A. S. E., and was distributed by him to N. A. S. E. associations for the convenience of the members. Bear in mind that if your application for an engineer's or fireman's license is not received by the Secretary of Labor by Sept. 4 you must stand examination. Space at the bottom of the blank is provided for the signature of employers as required by the law.

⁂

Melms and Pfenniger are making a 2500-kw. turbine, which they guarantee to run on 11 lb. of steam per kw.-hr. with an initial pressure of 14 atmospheres, 250 deg. F. superheat and 28 in. vacuum. The blading section is only about three feet long and consists of two velocity stages (Curtis) and a number of Zoelly pressure stages. It is single flow with a single dummy piston of sufficient diameter to balance the entire end thrust.

A Comparison of Piston-Rod Packing

By W. E. Sanders

SYNOPSIS—A brief description of various kinds of piston-rod packings, and their adaptability for the service. A comparison is made regarding the cost and wearing qualities of the several kinds.

⁂

Every engineer or superintendent is vitally interested in minimizing the power-plant operating expenses. This is his chief problem and one that is never solved satisfactorily because there are always opportunities arising for producing economy that have been overlooked.

When it comes to supplies that are used up and renewed, such as coal, water softeners, oil, grease, packing, etc., the problem becomes complex and admits of no very exact or definite answer. The packing problem is such that it is impossible to obtain a solution that will be applicable to every installation, since the conditions are not the same in any two plants.

A near-sighted purchaser only sees the price per pound and the expense sheet is a month-to-month affair. The far-sighted purchaser pays little heed to the initial cost, but looks at the operating expense figured over a lapse of six months, or a year or years, and sees a relation between his expense for oil, grease or packing and the items for coal and repairs. Looking at the pound price only the answer is simple—buy the cheapest and forget overtime work, repairs and increased loss of work due to increased friction, which loss shows decidedly in the amount of fuel used.

The far-sighted buyer chooses a packing that works with the least possible friction, thus reducing to a minimum the friction loss and unnecessary consumption of steam or coal. He will consult with his engineer in making his choice of packing and see to it that he knows the proper way to use that kind of packing and not abuse it. Packings need constant lubrication to prevent burning and that should be insisted upon.

Having chosen the kind of packing, it remains to pick out the brand. This requires an analysis or tearing apart of the packing to determine the quality of the material as well as the workmanship; the best material and best workmanship will be the most economical in the end. A number of different brands may all hold back steam equally well, but some one will last the longest and that one, conditions being the same, will be the best to use.

Having purchased a particular brand of packing, it is well to start a record for each engine, at once, showing the hours run and the cost of packing for that machine. A good plan is to reserve some small duplex pump as a test machine, and test any new brand of packing on this machine before buying for stock. It is thus possible to eliminate poor packings at a very small expense.

In the instance of some rod packing, the pressure on the rod is produced by pressure from a gland, and is dependent upon the judgment of the operator. Often excessive pressure is applied and unnecessary friction is produced.

Moisture-expanding packings are generally composed of flax, either alone or in combination with duck. They are open to the same objection as gland-pressure packings, although, if properly used, the probability of excessive pressure is greatly reduced.

Heat-expanding packings are composed of rubber and duck. A good type contains rubber which acts as a cushion in the back of the packing. When cold the packing will leak; when hot it will have expanded and only a gentle pressure is produced on the rod. To get an excessive pressure on the rod, the packing must be compressed by the gland, which is positively wrong. It is superior to the preceding kinds of packing, but is really successful only on steam or when used in hot stuffing-boxes.

Automatic packings are ordinarily known as "diagonals." The pressure on the rod is caused by the pressure within the cylinder and varies with it; consequently, only the necessary pressure on the rod is produced and all the excessive pressure is eliminated. It is a very economical nonmetallic packing, from the standpoint of steam economy.

Soft metallic packing, which is a soft, babbitt-like metal, put up in various forms, will work well under good conditions of rod alignment, but, when once set, is hard and has no resiliency to adjust itself to faulty alignment, thus an elliptical hole is worn from which steam will escape. Hard-metal packing with wedge-shaped rings gives good service, but is more complicated than other hard-metal packings Hard-metal packing, with rectangular flanged rings, made in segments and held together by garter springs, gives excellent service.

Tests of packings, used on a small vertical engine, showed a friction load that was due almost entirely to the packing, as follows:

Gland-pressure packing, about 9 per cent. of the full load; heat-expanding packing, about 7 per cent., and automatic packing, between 8½ and 4 per cent. These results would probably not be the same on larger units, but they show clearly that the friction of packing of the gland-pressure type is over twice as much, and heat-expanding packing nearly twice as much as that of automatic or diagonal packing from the standpoint of steam economy.

The data on the friction of metallic packings are not complete enough to establish a reliable comparison, but it seems that the friction of a first-class metallic packing would be quite low and that it would rank in the same class as automatic packings in steam economy.

If unintelligent or cheap labor is employed it may not be advisable to use a high-grade packing, but ordinarily the best is the cheapest. Taking automatic packing and hard-metal packing with rectangular flanged rings as a basis interesting comparisons can be made. Assuming the cost of metallic packing for a 4-in. rod as $40, the automatic packing to fill this stuffing-box once would cost about $2. But this particular brand of soft packing has been known to last from one month to 3½ years; this latter service is rather exceptional. Taking three months as ordinary service, the soft packing would cost $8 a year, and at the end of five years the metallic packing would have paid for itself.

As metallic packing usually lasts much longer, this comparison is only suggestive. Each case must be figured out from its own records. If delays for repacking mean much loss or if continuous night-and-day service is necessary, the question is already settled in favor of the metallic packing, provided that it be of the best type.

It is as impossible to say just how much packing should cost per year as to say how much a man should spend per year for clothing; the service must be considered as well as the personality of the man using the goods. A systematic record for a year or two will give a basis for facts, and a preliminary study into the principles and construction will throw light on the factor of steam economy. Careful examination of various brands will insure a good start and save time, and after this the actual records will furnish grounds for deciding on what is best.

⁂

A Stumpf uniflow engine is producing 6600 hp. in a single cylinder at the works of Ehrhardt & Sehmer, at Scheibfmuhle, near Düsseldorf.

⁂

Interborough 30,000-Kw. Steam Turbines

An order has just been placed with the Westinghouse Machine Co., by the Interborough Rapid Transit Co., of New York City, for three 30,000-kw., horizontal, double-flow steam turbines, the generator ends of which will deliver three-phase, 25-cycle current. The high- and low-pressure elements will be in separate casings.

These units, with a total output of 90,000 kw., will replace three of the 5000-hp. angle-compound engines now being operated in the 59th St. station and the three low-pressure turbines operating on the exhaust steam from these engines. The combined 90,000-kw. turbine units will be accommodated within the space now occupied by the old engines.

No additions will be made to the boiler equipment, other than that the present boilers will be equipped with greater stoker capacity than hitherto to enable the boiler to produce the additional steam required by the larger generating units.

⁂

Universal Craftsmen's Meeting

The tenth annual convention of the Universal Craftsmen Council of Engineers, was held at Boston, Mass., Aug. 5 to 8. The headquarters were at the Hotel Brunswick, and the several sessions of the delegates were held in the large banquet hall. There were about 180 delegates in attendance, and the business of the convention was conducted with harmony and dispatch.

The opening exercises took place at 11 o'clock on Tuesday morning, with George W. Knowlton in the chair. After the invocation by P. H. Early, grand chaplain, the address of welcome was made by Mayor John F. Fitzgerald, James U. Bunce, responding for the engineers. Interesting speeches were also made by William K. Campbell, president, Boston Engineers' Blue Room Club; Walter S. Cadwell, past worthy chief; Bradford L. Ames, president New England Association of Commercial Engineers, and Henry C. Senn, deputy grand chief.

At the close of the speeches the convention went into executive session, and after the various committees were appointed, an adjournment was taken until Wednesday morning at 9:30.

There was a varied program of entertainment, including auto trips through the shopping districts and park system, and other sight-seeing journeys.

On Tuesday evening the convention enjoyed a steamboat excursion to Nantasket Beach, the guests of the New England Association of Commercial Engineers.

On Wednesday afternoon, Everett C. Benton, grand master of Masons of Massachusetts, received the delegates and friends at the Masonic Temple.

On Wednesday evening the delegates and visitors were the guests of the Engineers' Blue Room Club, of Boston, on a trip to Revere Beach.

The principal feature of enjoyment was the reunion and entertainment on Thursday evening in the banquet hall of the hotel. A most enjoyable program of music, song and recital was given. Besides the local talent, Billy Murray, of Jenkins Bros., and Jack Armour, of "Power," gave numbers.

At the closing session of the delegates the following grand officers were elected: James U. Bunce, past worthy chief; Henry C. Senn, worthy chief; William H. Armstrong, assistant worthy chief; Charles F. Seigrist, secretary; Nathan J. Burdick, treasurer; O. N. Pomeroy, historian; H. E. Terry, warden; Frank M. Townsend, guard; P. H. Early, chaplain;

ATTENDANTS AT THE MEETING OF THE UNIVERSAL CRAFTSMEN, COUNCIL OF ENGINEERS, BOSTON, MASS.

Samuel J. Hunt, chairman board trustees; George C. Adwers and John MacMorran, trustees.

Cleveland, Ohio, was chosen as the place for the 1914 convention.

A fitting conclusion to the convention was the formation of a new council in Boston on Saturday night.

Canadian Engineers' Convention

The 24th annual convention of the Canadian Association of Stationary Engineers was held at Owen Sound, Canada, July 29, 30 and 31. The several sessions of the delegates were held in McLinden Hall, the lower floor of which was arranged and decorated for the use of the exhibitors' association of the C. A. S. E. for their mechanical display. There was a good attendance of delegates and visitors, and the reading of the reports of the committees showed the organization to be in a sound condition.

The opening exercises took place on Tuesday morning, Executive President J. A. Robertson introduced Mayor Elias Lemon, of Owen Sound, who welcomed the convention to the city. August Kastalla responded for the engineers and James E. Fiddes for the exhibitors. The delegates then went into executive session.

There was an enjoyable entertainment. On Tuesday even ing the local lodge gave a banquet at which covers were lai for about 200 ladies and their escorts. After the dinner wa served Toastmaster Fred Harrison introduced the followin gentlemen, who made interesting and enjoyable addresses Mayor Lemon, W. A. Crockett, W. S. Middlebro, M. P., C. S Cameron, M. P., John Parker, James E. Keenan, W. E. Hoovey "Dad" Wickens and James Rutherford. During the evenin the following entertainers appeared: The Leslie trio, Harr Brown, W. S. Mann, John and Nellie McKeen, Horace Merry Simms Brothers, J. E. Fiddes, E. F. Heatherington and Joh W. Armour.

On Wednesday afternoon an excursion by steamer wa made to Kings Royal Park, where outdoor sports of all kind were indulged in. There were prizes for the winners of eac event. The baseball game between the Manufacturers an Engineers resulted in a victory for the latter by a score o 8 to 7. At the conclusion of the games dinner was served a the King's Royal Hotel, and after a short entertainment dancing was enjoyed. There were also automobile trip about the city for the ladies.

At the closing session the following executive officer were elected: James A. Robertson, past president; Samuel E Cosford, president; A. W. Heath, vice-president; August Kas

DELEGATES AND GUESTS AT THE C. A. S. E. CONVENTION, OWEN SOUND, CANADA, JULY 29, 30 AND 31

talla, secretary; W. E. Archer, treasurer; J. Dyson, conductor; W. E. Hovey, doorkeeper.

The following officers were elected by the Exhibitors' Association: Ernest A. Wilkinson, president; A. C. Pulver, first vice-president; Boswell M. Walthall, second vice-president; B. G. Newton, treasurer; Gordon C. Keith, secretary; James N. Charles, assistant secretary; Earl F. Heatherington, chairman of executive committee; C. P. Archibald, chairman of entertainment committee; Carl N. Schrag, chairman of reception committee.

A silver-mounted casserole was presented to Joseph McLinden, and Ernest Hovey received an umbrella.

THE EXHIBITORS

The Lunkenheimer Co.
Canadian Morehead Manufacturing Co.
Standard Sanitary Manufacturing Co.
Dart Union Co.
T. McAvity & Sons.
Canadian Allis-Chalmers Co.
Canadian H. W. Johns-Manville Co.
Hugh C. MacLean Publishing Co.
Perolin Co.
Turner & Tupper.
Peerless Rubber Manufacturing Co.
Canadian Fairbanks-Morse Co.
Dearborn Chemical Co.
E. Leonard & Sons.
Garlock Packing Co.
Ontario Lantern & Lamp Co.
Quaker City Rubber Co.
Goldie & McCulloch Co.
James Morrison Brass Manufacturing Co.
"Canadian Manufacturer."
"The Power House."
"Power."

Ottawa, Ont., was chosen as the next place of meeting in July, 1914.

NEW PUBLICATIONS

LOGARITHMS FOR BEGINNERS. By C. N. Pickworth. Published in America by D. Van Nostrand Co., New York, 1913. Fourth edition. Cloth, 49 pages; 7¼x5 in. Four tables. Price, 50c.

The purpose of this book is to put before readers a treatise on logarithms in a style easily comprehended by the average student. As the title indicates the book is primarily for beginners.

The explanations of negative quantities and the arithmetical complement are excellent. The reader gets a brief but forcible account of the purpose and use of exponents, indices, and of what a reciprocal of a number is. To beginners these terms are perplexing and too many writers of textbooks fail to be elementary enough in their descriptions of them. Mr. Pickworth has avoided this offense.

A short table of four figures of common logarithms is given so the student may practice in the use of such tables. A table of hyperbolic logarithms is also included.

Altogether the book gives a more practical treatment of logarithms than is found in most mathematical textbooks.

EVOLUTION OF THE INTERNAL-COMBUSTION ENGINE. By Edward Butler. Published by Charles Griffin & Co., Ltd., London, and by J. B. Lippincott Co., Philadelphia. Cloth; 237 pages, 6x9 in., illustrated. Price, $3, net.

This is not a historical sketch of the internal-combustion engine, as might be inferred from the title, but instead, treats of the more important problems of design as met in the modern oil and gas engine. Chapters are devoted to the following divisions of the subject: Four-stroke-cycle engines, scavenging, two-stroke-cycle engines, compound explosion engines, thermodynamic considerations, internal-combustion turbines, admission and exhaust valves, methods of governing, carburetion, cooling and lubrication.

Large gas and oil engines are discussed to some length both from an economic and a constructive point of view. Special types of small motors such as the sliding sleeve and revolving-cylinder types are also taken up.

Nearly two hundred illustrations are included, and these are well chosen, but in point of criticism, it may be added that the drawings are very poorly executed.

The book is not an elementary treatment of the subject, but is intended for those already familiar with the principles of gas and oil engines. As such it serves a useful purpose in setting forth many of the problems of design and the ways in which they have been met by previous designers.

SAFETY METHODS FOR PREVENTING OCCUPATIONAL AND OTHER ACCIDENTS AND DISEASE. By William H. Tolman, Ph. D., Director of the American Museum of Safety, and Leonard B. Kendall. Published by Harper & Bros., New York, 1913. Size 5½x8½; 422 pages; cloth. Price $3.

The question of safety is taken up from both a social and an economic standpoint and it is estimated that the annual loss in this country alone through industrial accidents amounts to approximately $250,000,000, half of which is preventable in the opinion of those who have given the subject careful study. It is also shown that the average compensation is $400 of which the plaintiff's lawyer usually receives half.

A brief review is given of how the problem is handled in Germany. Every German employer belongs to the trade association of his business and he pays into this association a premium to insure his workmen's safety, the amount being determined by the size of his payroll and the risk of his business. In the event of an accident to one of his employees, an investigation is made by his associates and if blame attaches to the employer he is heavily fined.

The book takes up in detail various classes of industries including steelworks, mining, electrical accidents, cutting and grinding tools, illumination, fire protection and prevention and general aids to safety. Under the heading "Industrial Hygiene" is shown how committees on sanitation are at work, the effects of industrial poison, and the ways in which they may be prevented or reduced to a minimum.

The work of the Museum of Safety along the lines of industrial education is gone into fully. A number of carefully selected illustrations add to the attractiveness of the book and forcibly emphasize the arguments laid down in the text.

Methods of Analyzing Coal and Coke

Technical paper 8 on "Methods of Analyzing Coal and Coke," by Frederic M. Stanton and Arno C. Fieldner has just been issued by the Bureau of Mines. In January, 1912, the first edition of this paper was published, but due to a number of inquiries for additional information in regard to details of sampling or analytical work that were not discussed at length in that edition and because the bureau has modified and improved various details of its laboratory practice the present paper was issued. Some radical changes were made in the text matter, and several new illustrations added. The paper first takes up the preliminary treatment of samples and continues with the method of calculating and recording analyses, method of analysis, determination of the calorific value of coal, determination of the true specific gravity of coal and coke substance and determination of the apparent specific gravity. The subjects are fully discussed and illustrated so that the paper should meet all needs.

Smokeless Combustion of Coal in Boiler Furnaces

The Bureau of Mines has just issued Bulletin 40, which is a reprint of U. S. Geological Survey Bulletin 373, revised by Henry Kreisinger. The authors of the original bulletin were D. T. Randall and H. W. Weeks. The Bureau of Mines has made extended tests to determine the conditions necessary for the smokeless combustions of bituminous coal in boiler furnaces. In the investigations of industrial establishments a study was made of the conditions in 13 of the larger cities in Illinois, Indiana, Kentucky, Maryland, Michigan, Missouri, New York, Ohio and Pennsylvania, between 400 and 500 plants being inspected. Sufficient information was collected to make the data from 284 plants of value for this report. In nearly every city visited coal was supplied from points both in and out of the state, so that although nine states were visited the facts ascertained apply to coal from a greater number. The main purpose of the inspection was to obtain a better knowledge of the influence of furnace design, and of the conditions under which combustion takes place, on the production of smoke. The summary of conclusions as given in the Bulletin will indicate what was learned by the tests.

A furnace, well designed and operated, will burn many coals without smoke up to a certain number of pounds per hour, the rate varying with different coals, depending on their chemical composition. If more than this amount is burned, the efficiency will decrease and smoke will be made, owing to the lack of furnace capacity to supply air and mix gases.

Extremely high volatile matter in the coal usually gives low efficiency. The highest efficiency was obtained when the furnace was run at low capacity. When the furnace was forced the efficiency decreased.

With a hand-fired furnace the best results were obtained when firing was done most frequently, with the smallest charge.

Small sizes of coal burned with less smoke than large sizes, but developed lower capacities.

Peat, lignite and sub-bituminous coal burned readily in the type of tile-roofed furnace used and developed the rated capacity with practically no smoke.

Coals that smoked badly gave efficiencies 3 to 5 per cent. lower than the coals burning with little smoke.

Briquettes were found to be an excellent form for using slack coal in a hand-fired plant. They can be burned at a fairly rapid rate of combustion with good efficiency and with

practically no smoke. High-volatile coals when briquetted are perhaps as valuable as low-volatile coals when not briquetted.

A comparison of tests on the same coal washed and unwashed showed that under the same conditions the washed coal burned much more rapidly than the raw coal, thus developing high rated capacities. In the average hand-fired furnace washed coal burns with lower efficiency and makes more smoke than raw coal. However, washed coal offers a means of running at high capacity, with good efficiency, in a well designed furnace.

Forced draft did not burn coal any more efficiently than natural draft. It supplied enough air for high rates of combustion, but as the capacity of the boiler increased the efficiency decreased and the percentage of black smoke increased.

Most coals that do not clinker excessively can be burned with 1 to 5 per cent. greater efficiency and with a smaller percentage of black smoke on a rocking grate than on a flat grate.

Air admitted freely at firing and for a short period thereafter increases efficiency and reduces smoke.

As the CO in the flue gas increases, the black smoke increases; the percentage of CO in the flue gas is therefore, in general, a good guide to efficient operation. However, owing to the difficulty of determining this factor, combustion cannot be regulated by it.

Very complete data are tabulated in the bulletin, and a number of types of furnace and methods of baffling are illustrated. A chapter on "Central Heating Plants" is also included.

SOCIETY NOTES

The annual outing and clambake of No. 7, N. A. S. E., of New York, at Douglaston, L. I., on Sunday Aug. 3, was the largest in the history of the association. About 300 ladies and gentlemen enjoyed the dinner.

On Sunday, Aug. 10, Stevenson Association No. 44, N. A. S. E., of New York, held its outing at Grant City, S. I. There was the usual large attendance. There were outdoor sports of all kinds, and dancing concluded the day's fun.

The 18th anniversary reunion and field day of Pawtucket Association No. 2 of the National Association of Stationary Engineers, was held at Palace Gardens on Narragansett Bay, R. I., on Sunday, July 27. Fully 400 were in attendance and a most enjoyable day was spent. After the clambake the company adjourned to the pavilion, where the "Bunch" gave an entertainment. The feature of the day was the baseball game between the Pawtucket boys and the "Bunch," the latter winning by a small margin after a most exciting game.

PERSONALS

C. C. Witt, for two years engineer with the Kansas Public Utilities Commission, has resigned to accept service under the Interstate Commerce Commission. T. J. Strickler succeeded Mr. Witt as engineer with the Kansas Commission.

J. F. Mallory, formerly with the Taylor Stoker Co., is now connected with the B. F. Sturtevant Co. at the New York office, 50 Church St., makers and selling agents of the Riley self-dumping underfeed stoker for the Sanford Riley Stoker Co., Worcester, Mass.

OBITUARY

Eugene O. Reuleaux died suddenly of heart failure at Indianapolis, Ind., Aug. 6, 1913.

He studied mechanical engineering in Berlin under his father, Prof. F. Reuleaux, author of "The Constructor," until about the age of 16, when he came to the United States, settling in St. Paul.

He has held many important positions with the Westinghouse Machine Co. and Dodge Manufacturing Co., and a short time before his death was general superintendent of the American Rotary Valve Co., of Anderson, Ind. He left a wife and two sons.

BUSINESS ITEMS

The American Engineering Co., Philadelphia, Penn., ha recently booked orders for 20 installations of Taylor stokers seven of which represent repeat orders.

The Avery Scale Co., North Milwaukee, Wis., has engage C. A. Weaver for its representative in the Northwest, wit headquarters at Room A-1 Chamber of Commerce, Minne apolis, Minn.

The B. F. Sturtevant Co., Hyde Park, Mass., has arrange for a plant in Galt, Ont., to handle the company's business i Canada and also to export to England, Australia and othe foreign countries.

The Springfield Boiler & Manufacturing Co., Springfield Ill., has purchased the rights, patents, and good will of th Flanner water-tube boiler, which was previously built by th Toledo Flanner Boiler Co., of Toledo, Ohio.

The Terry Steam Turbine Co., Hartford, Conn., have ap pointed Hoshall, Simmons & Co., 502 Randolph Building, Mem phis, Tenn., as their agents for that city and the territory o Tennessee, Arkansas, and the northern part of Mississippi.

The Yarnall-Waring Co., Chestnut Hill, Philadelphia, Penn is sending out free a very attractive cardboard model of th Simplex seatless blow-off valve. This model gives an ex cellent idea not only of the construction, but also of th operation. The company will be glad to send one of thes models to any "Power" reader on request.

Contrary to prevailing opinions on conditions throughou the country, some manufacturers are almost overwhelme with business. The Terry Steam Turbine Co., Hartfor Conn., has just started operating on a 23-hour per day basi the one hour of idleness being from six to seven in th morning. It is found necessary to do this in order to clea the shop from the present crowded condition, due to conges tion of orders during the past few months. June is reporte to have been the biggest month ever experienced by th company.

Owing to the rapid growth of the Elliott Co., Pittsburgh their present works have been for some time entirely inade quate. They have recently purchased the works of the Clu Ford-Capell Run Co., at Jeannette, Pennsylvania, and are no engaged in remodeling the buildings, and making them suit able for their regular line of business, and in addition ar preparing to construct a new foundry, 300x150 ft. The ne works are located on 33 acres of ground adjacent to Jeanett and the buildings already in place will represent an increas in floor space of about 2½ acres. They expect to comple their improvements and additions to their new works b October, after which at least their heavier tools will b moved to that plant.

The Bruce-Macbeth Engine Co., Cleveland, Ohio, has re cently booked the following orders for their vertical mult cylinder gas engines: Two 100-hp. four-cylinder engines fo the Snow Steam Pump Works for installation in Louisian one 60-hp. twin cylinder engine for the American Glove Co Dunkirk, N. Y.; one 150-hp. engine for the Interstate Cotto Oil Refining Co., Sherman, Tex. Among recent shipment were one 150-hp. engine for the Fry Glass Co., Rocheste Penn.; one 150-hp. for John Eichlay, Jr., Pittsburgh, Penn and one 350-hp. for the Sydenham Glass Co., of Canada.

The growth of the business of the Coppus Engineering Equipment Co., Worcester, Mass., has compelled the remova to new and larger shops at 166 Union St.

Manning, Maxwell & Moore, Inc., of New York City, to gether with their subsidiary companies, will move their ge eral offices on or about Oct. 1, from 85-89 Liberty St., to th new Newsom Building, 113-119 West 40th St. (near Broad way, and running through to 114-118 West 41st St.) Th change is being made to meet for a more convenient an central location, as well as larger space to handle materi increases in their various lines, which cover electric trave ing cranes, machine tools, engineering specialties, railwa machinists', engineers', factory and contractors' supplies. large portion of this product is manufactured by their co stituent companies: The Shaw Electric Crane Co., the Ash croft Manufacturing Co., the Consolidated Safety Valve C the Hayden & Derby Manufacturing Co. and the Hancoc Inspirator Co. They will occupy the 20th and 21st floors the above building, which will give them 28,000 sq.ft. space. This space will be exclusively for offices, and is almo double that at present occupied for offices on Liberty St.

TRADE CATALOGS

S. F. Bowser & Co., Inc., Fort Wayne, Ind. Pamphlet. collapsible oil filter. Illustrated, 24 pages, 6x9 inches.

The United States Graphite Co., Saginaw, Mich. Bookle "What Users Say About It." Mexican boiler graphite. Illu trated, 64 pages, 5x8 inches.

The Vilter Mfg. Co., Milwaukee, Wis. Bulletin No. "Plate Ice and Raw Water Can Ice as Affected by the Mi eral Salts in Water." 20 pages, 6x9 inches.

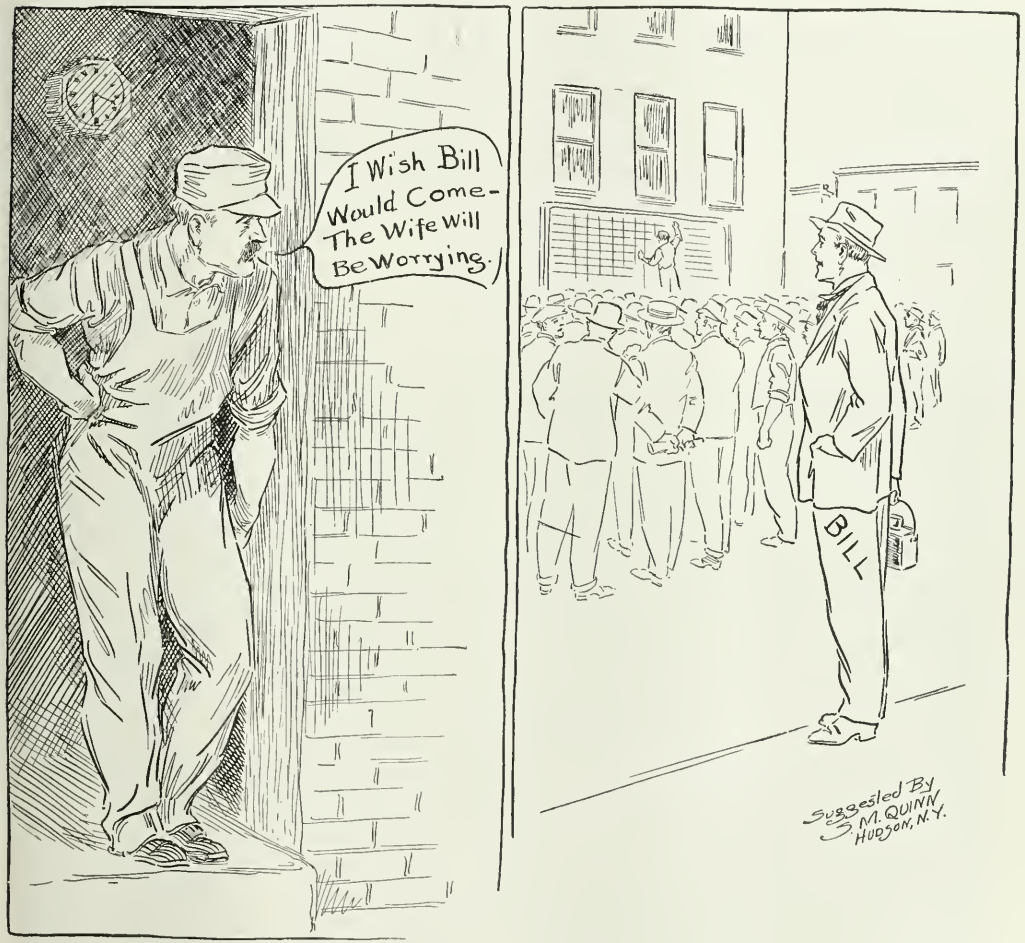
National Tube Co., Frick Building, Pittsburgh, Pen Booklet. The Whole "Kewanee" Family. Unions, union el and tees, boiler couplings, etc. Illustrated, 48 pages, 5½ inches.

Hughson Steam Specialty Co., First National Bank Buil ing, Chicago, Ill. Catalog D. Eclipse steam specialti Valves, pump governors, water columns, steam traps, e Illustrated, 40 pages, 5½x8½ inches.

Harrison Safety Boiler Works, 17th St. & Allegheny Av Philadelphia, Penn. Catalog Section A. Live steam separ tors. Illustrated, 20 pages, 6x9 inches. Catalog Section Live-steam separators and receivers. Illustrated, 32 pag

POWER

Vol. 38 NEW YORK, AUGUST 26, 1913 No. 9



THE TARDY RELIEF

New York City's Power Problem

By A. D. Blake

SYNOPSIS—The group of city buildings adjacent to the Hall of Records affords an excellent opportunity for a central plant for heat, light and power. Some of these buildings are already on service from the Hall of Records plant; whether the rest of the available load will be taken over will depend largely on the outcome of a year's test now being carried on at this plant.

The long-controverted question as to whether New York City can more economically operate its own steam plants or purchase electrical energy and perhaps steam from outside sources is being carefully investigated through a test now being conducted on the plant at the Hall of Records at Chambers and Center Streets.

Tests extending over periods of several days or even weeks have not been uncommon in the past, but this, we believe, is the first instance of a complete plant test extending over a whole year and thus making available complete operating data for all seasons. Aside from arriving at the cost of producing electric energy, and its ultimate importance to the city, the test will go far toward showing what proportion of the total cost should be credited to exhaust-steam heating, hydraulic elevators, and various auxiliaries, conclusions about which have heretofore been largely a matter of conjecture.

Fig. 1. Hall of Records

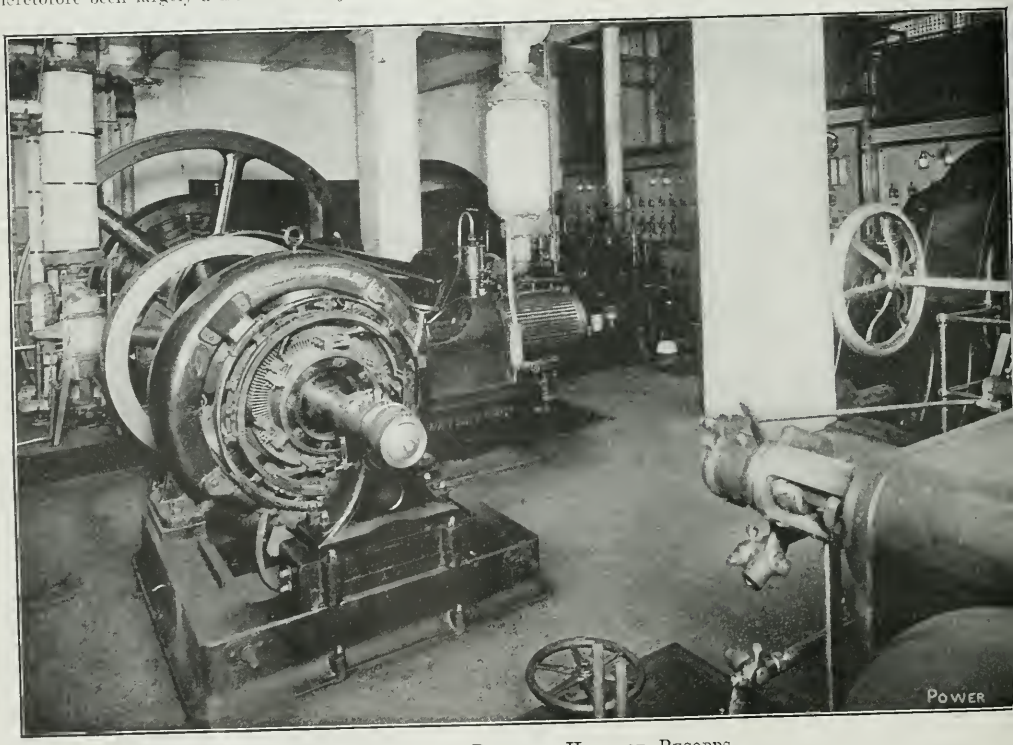


Fig. 2. Engine Room of Hall of Records

Reverting to the conditions leading up to the present test, a well equipped plant had been installed at the new Police Headquarters, but never operated, and other city plants, notably that at the Tombs prison, had been shut down about three years ago and Edison service substituted. These instances led to an investigation by the Bureau of Municipal Research, which, after compiling considerable data upon the operations of plants in the city, submitted an extensive report, which was favorable to the city-operated plant. This report, however, was open to attack, as it contained certain assumptions, which, in the absence of actual data, could not be satisfactorily substantiated.

To settle the question, it was finally decided to conduct a year's test on the plant of the Hall of Records under the general direction of the Bureau of Municipal Research, the New York Edison Co. and the city defraying the expenses. A board of six advisory engineers were selected, Professors R. C. Carpenter and C. E. Lucke representing the Bureau of Municipal Research, Messrs. R. P. Bolton and E. F. Tweedy the New York Edison Co., and Messrs. E. P. Goodrich and G. F. Sever the city. These selected Professor Diederichs, of Cornell University to conduct the test; he choosing his own observers from among Cornell students. The test was started Dec. 16, 1912, and the plant is being operated by the regular city employees, of whom John J. Daly is the chief engineer. Mr. L. R. Bates, mechanical engineer for the Department of Public Buildings, has general supervision over the operation.

The plant was installed in 1904 and the generators have a rated capacity of 450 kw. The equipment consists of five hand-fired B. & W. boilers, having a total capacity of approximately 1100 hp.; two 18x42-in. and one 16x36-in. Brown Corliss engines, direct-connected, respectively, to 150- and 100-kw., 120-volt, direct-current generators. In addition to these there is a 12x13-in. Watertown engine, driving a 50-kw. dynamo. All are noncondensing and exhaust to the heating system during the heating season. In the summer months, part of the exhaust is used in the 10-ton absorption-type refrigerating machine, which is used for cooling the drinking water.

There are six hydraulic elevators for passenger service,

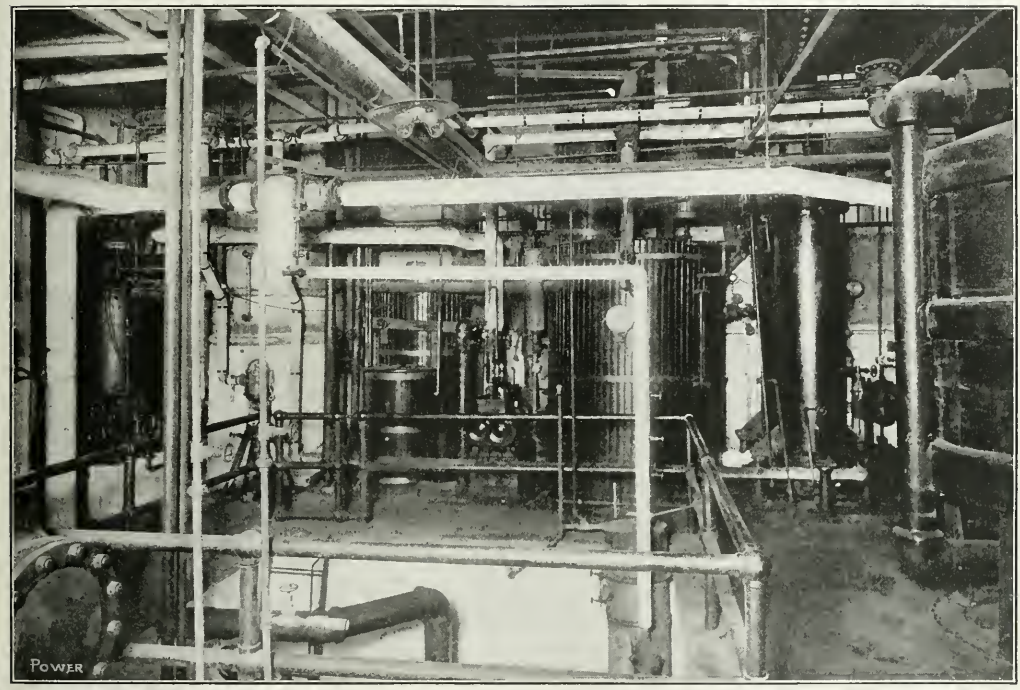


FIG. 3. REFRIGERATING MACHINE

four book lifts and one sidewalk ash lift. The book lifts, however, are not used. This service is handled by three 16 and 25x12x15-in. compound-piston pumps and one 9x4x10-in. ram for safe lifting. This pumping plant also serves two hydraulic passenger elevators in the City Court Building.

A 57-cell, 1000-amp.-hr. storage battery is provided for night service during the summer months. In the heating season the 50-kw. generating unit is operated at night as the exhaust steam is utilized in the heating system.

In the present test water, steam and electric meters have been placed on all lines and circuits, within the building, as well as those supplying outside service, so that each part of the plant may be charged with its proper share of the load. Readings are taken every hour

and all classes of meters are calibrated at stated intervals.

Recording thermometers are placed on the feed-water lines and the cooling water returns, and there are indicating thermometers on all water-meter lines.

Two different types of CO_2 recorders are provided, one as a check upon the other, and there is also a smoke recorder installed in the boiler room, where it may be seen by the firemen at all times. All coal and ash are carefully weighed by the observers and the evaporation is posted from day to day on the blackboard in the fire-room, so that the firemen may know just what they are doing; this also has had the effect of stimulating competition among the firemen.

The plant is now being operated very satisfactorily with 15 men, including the chief, which is six less than in 1911, when conditions were somewhat different. Moreover, the same service is being performed with one less boiler, two being used in summer and three in winter. In line with the policy of the present administration, many economies have been effected, such as the use of exhaust steam in the refrigerating system, where live steam was formerly used, and the installation of a motor-driven air-compressor for the ejectors in place of the more uneconomical steam compressors previously used. Moreover, the heating and ventilating fans in the County Court House were changed from engine drive to motor drive, since with the engine drive it was necessary to use high-pressure steam from the New York Steam Co.

Exact figures as to operating costs will not be available until after the test has been completed. The overhead and fixed charges will be determined separately by the advisory board of engineers and will be added to the operating costs after the test has been completed.

The group of city buildings around the Hall of Records affords a splendid opportunity for a block system of steam and electric supply. Prior to the summer of 1911, the City Hall, the County Court House and the City Court House were supplied with steam from the mains of the New York Steam Co. and with electricity from the New York Edison Co. At that time, however, these buildings were connected with the Hall of Records by underground piping and were supplied with steam, hot and cold water, and, in the case of the City Court House, with water for elevator operation. This, according to the report of Borough President McAneny, resulted in a saving of $18,000 in fuel and labor the first year alone.

The following summer, cables were installed in the ducts provided under Chambers Street and the Hall of Records supplied electrical energy to the group of buildings in City Hall Park.

Even with this additional load the electrical plant is considerably underloaded, one unit being able to handle the load for the greater part of the time, and after 4 p. m. the lighting load falls off very rapidly. Obviously, anything that would tend to increase the night load and thus raise the load factor, would be extremely desirable. Such an opportunity appears in the lighting service on the Brooklyn Bridge, which is only a few hundred feet from the Hall of Records. The Bridge lighting comes on just about the time that the load in the Hall of Records falls off, and is at present on Edison service, but, as we understand, the contract is made from year to year, and could be very easily taken over by the city.

The most important proposition, however, is with regard to the new Municipal Building, located just across the street from the Hall of Records. The electrical requirements of this building will be considerable as, in addition to the lighting, there are thirty-four electric elevators, and it is expected that it will be ready for occupancy during the coming winter. In its basement there have been installed about 1700-hp. in high-pressure boil-

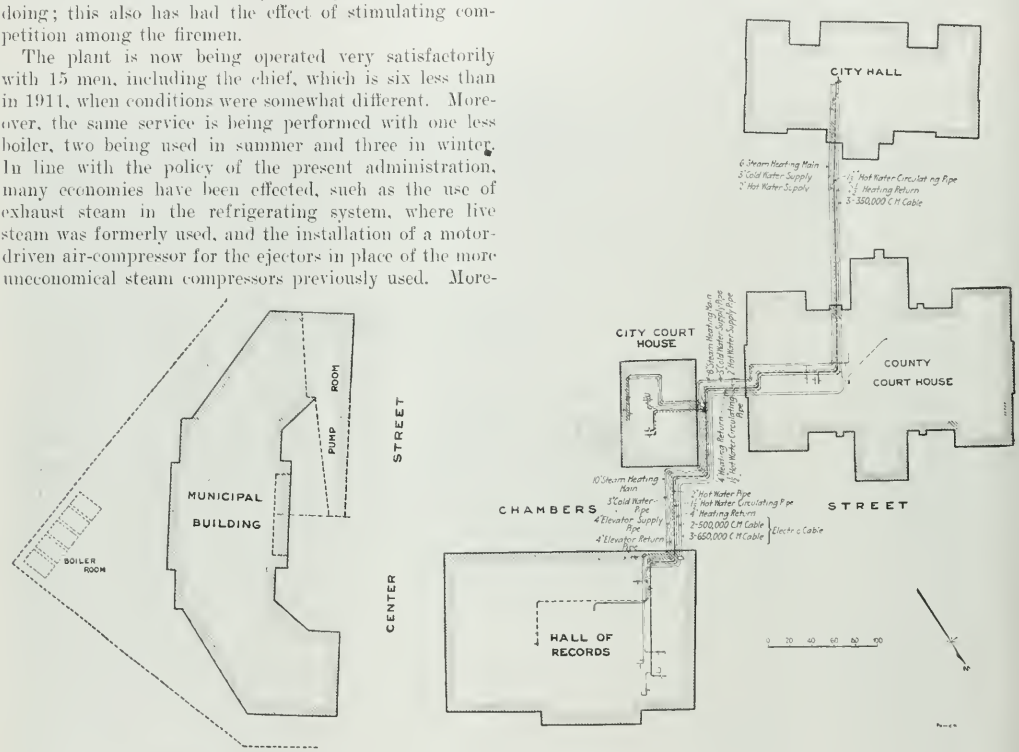


FIG. 4. PLAN SHOWING RELATIVE LOCATION OF CITY BUILDINGS AND SERVICES ALREADY INSTALLED

GROUP OF CITY BUILDINGS IN AND AROUND CITY HALL PARK

ers, with a complete pump equipment for various services and a 25-ton ice machine, but no engines or generators. A very complete switchboard has been installed, and Edison service is connected. Owing to the subway passing through the basement of this building, the space is somewhat cut up, as may be seen from the general plan, Fig. 4, and it was a question at the time whether enough space was available for an engine room. At any rate, the engines and generators were omitted.

Such being the conditions, it seems only logical to run a tunnel under Center Street and connect the boilers with those of the Hall of Records, installing such additional units as may be necessary in the basement of the latter building, where there is plenty of room, and supplying both buildings from the one plant, an arrangement which would cut down both labor and fuel expenses. The final outcome as to this suggestion may be governed by the results of the present test in the Hall of Records.

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Elliott Vertical and Horizontal Heaters

These heaters contain the combined desirable features of the old Pittsburgh feed-water heater and numerous improvements made by the present manufacturers of the Elliott heater, the Elliott Co., 6908 Susquehanna St., Pittsburgh, Penn.

An examination of the accompanying illustrations shows simplicity of design and convenience in operation. With the exception of the bolts and brass fittings the heaters are built entirely of cast-iron.

The vertical heater, Fig. 1, is made with dished upper and lower heads, the top head being provided with a vent for removing accumulated air and gases in the heater. There is also an enlarged passage between the inlet nozzle and the heater, at the top of which is a combined oil separator and cutout valve. The oil and entrainments abstracted from the exhaust steam by the separator pass into an overflow box, below, from where it flows to waste through a water-sealed opening. The overflow box not only serves as a deposit chamber for the condensation and oil, but the large opening in its front face next to the water provides an overflow and skimmer to the heater. If back pressure is carried on the heater, the outlet to this chamber is provided with a float-actuated trap.

Water is admitted through a balanced valve controlled by a ventilated float, and is discharged through a cast-iron conduit to the spray box, from which it is discharged to the pans. This spray box has four or more V-shaped arms with saw-tooth edges, Fig. 2, over which the water flows to the top distributing pan. Because of the construction of the pans the water is broken up as it passes over and drops into the water space below, during which passage it reaches its maximum temperature.

Referring to Figs. 1 and 4, water drops from the arms of the spray box into the distributing pan and then flows in an outward direction, falling from cascade to cascade until it passes over the outer edge into the sediment pan below. It then flows in an inward direction, falling on another cascade pan beneath, and so on until it finally drops into the water chamber. As the water falls over the edges of the cascade pans, it is broken up a number of times, and in approaching the outer edge its depth gradually decreases, until in the form of a thin sheet, it passes over the outer edge into the pan beneath.

The pans are supported on a central column and each individual set is rotatable about its center casting independently of the adjacent set. The cascade pans are made in two sections bolted together, and are not intended to be removed from the heater. The sediment pans, however, are built in segments, Fig. 5 the number and size depending upon the size of the heater. They are fastened to the cascade pans and are easily removable through cleaning doors on the side of the casings. The cascade pans consist of annular steps, the sediment pans

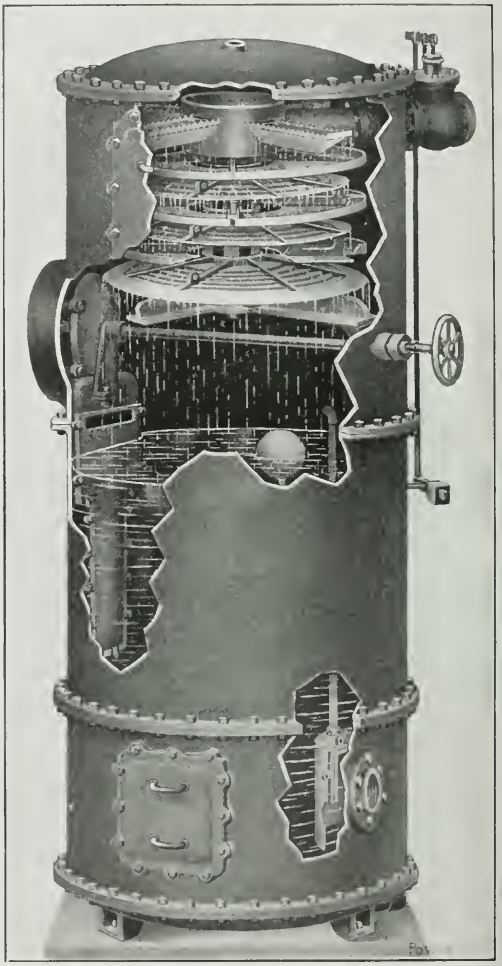


Fig. 1. Semi-Sectional View of Vertical Heater

slope toward the center and catch precipitates released by the heat of the water. In order to clean the pans each is rotated in front of the cleaning door, the absence of the sediment-pans segments allowing ample room for scraping off any scale that may have formed.

The combined separator plate and cutoff valve is shown in Fig. 6. It is made with a corrugated surface against which the incoming steam impinges, abstracting the oil and entrainment which are deposited in the overflow box.

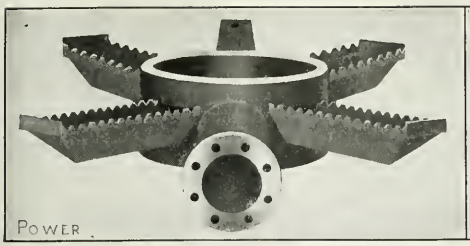


Fig. 2. Spray Box

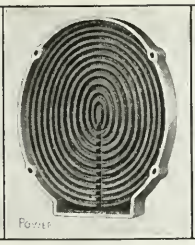


Fig. 3. Oil Separator

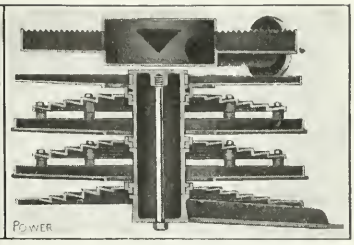


Fig. 4. Distributing Trays

The separator is mounted on studs and by removing the nut can be removed and cleaned after becoming filled with grease and oil. The face of the oil separator is shown in Fig. 3.

The cutoff valve permits of cutting out the heater for cleaning. A bronze ring inserted in one of the outer grooves of the oil separator acts as a valve ring and bears on the valve seat in the steam nozzle of the heater. The combined valve and separator slides on its supporting studs. One end of the valve stem extends through the separator and cross bar which is threaded and engages with the threads on the end of the valve stem, which is also connected to the valve spider. The other end extends through the wall of the heater and is provided with a valve wheel.

Cold water enters the heater through the inlet valve already mentioned, and the rising and falling of the float opens and closes the valve in a proportion sufficient to maintain a constant water level in the heater. The return condensate from the heating system enters the heater through an opening between the cold-water inlet valve and the heater, the condensate passing over the heating pans in the usual way to insure the highest temperature.

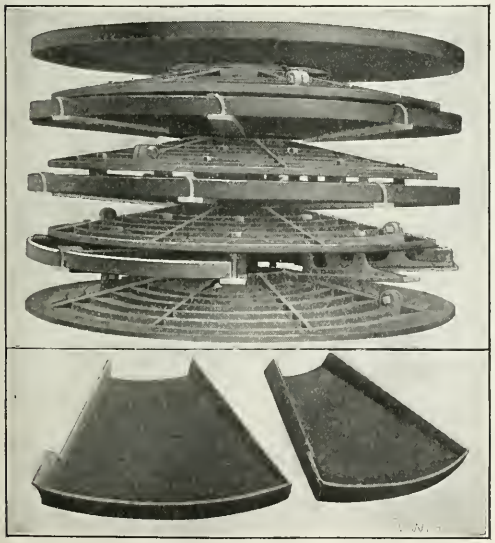


Fig. 5. Sediment Pans

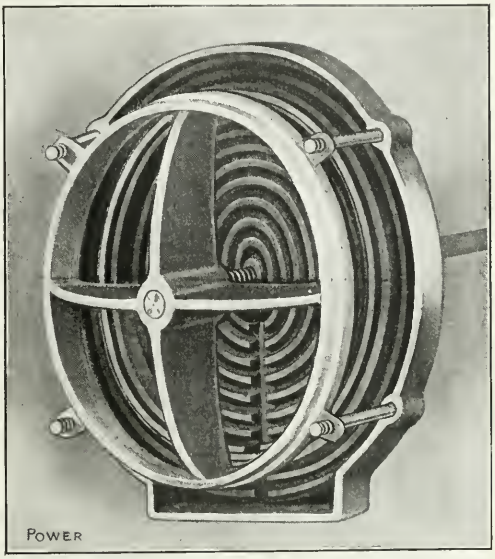


Fig. 6. Combined Separator and Cutoff Valve

To simplify piping a tee separator can be attached to the heater, the purpose of which is to purify the steam that does not enter the heater, but which is used for other purposes, such as steam drying, heating, etc. When the heater cutout valve is used and the steam is shut off from the heater all the steam is purified up to the capacity of the main exhaust line. The tee-type separator can be placed at any convenient point in the exhaust line leading to the heater.

This type of separator is also built in such a way that the valve and separator plate are in one piece so mounted that it can be readily removed through the opening at the top when it becomes fouled and requires cleaning. Fig. 7 shows a section through a tee-valve separator designed for a horizontal exhaust main. On one side of the tee is a separating plate containing a combined valve and valve disk operated by a valve stem which passes through one side of the tee. The outlet to the separating chamber is provided with a bronze seat for the valve disk.

A combination of tee-valve separator and back-pressure valve is shown in Fig. 8. The back-pressure valve is attached to the top outlet of the separator, when the

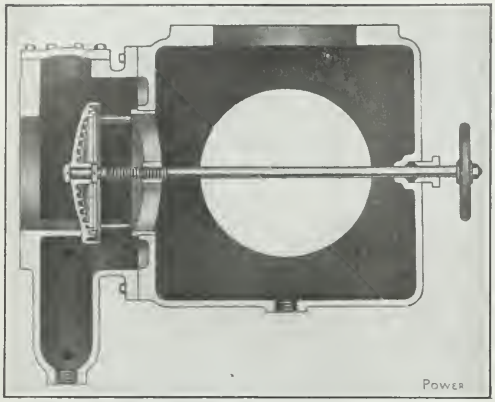


FIG. 7. SECTION OF TEE-VALVE SEPARATOR

apparatus is mounted on the heater. The control of the heater and heating or drying systems is centralized at the heater, as shown.

In the design of these heaters it will be noted that all the space within is utilized for maintaining the proper head of water above the pump suction, and for providing ample area for distributing the steam to the pans. There is also a sufficient amount of steam space between the walls and pans and between the different pans, to allow for the required supply of steam, as well as for a sufficient area of the water surface to permit of precipitating the impurities before the water is drawn from the heater and forced into the boiler.

These heaters are made in various types, vertical, rectangular, cylindrical and horizontal. The vertical rectangular heater is built in small sizes only, and is suitable for small installations, occupying, as it does, but very little floor space and headroom. The main body of this heater is made in one casting, the back is closed by a plate containing the nozzle, overflow, etc. The body and plate are bolted together; the pans, water supply and separators are built on the same lines as in the heater already described.

The horizontal cylindrical heater is designed for use in power plants where headroom is limited. It is built on substantially the same lines as the vertical type, the difference being that the shell is placed horizontally instead of vertically. A view of this heater is shown in Fig. 9. The flanged sections are cast, machined and bolted together; doors permitting access to the interior for cleaning are provided on the right-hand head, and on the side walls of the cylinders. Water enters the heater through a balance-float-controlled valve, shown at the right-hand head, and is discharged into a conveying trough, and distributed through adjustable nozzles to the several sets of pans. The nozzles can be adjusted to obtain an equal supply of water to each set of pans. The combined valve and separator already described is shown at the left, the valve being operated by a handwheel extending through the wall of the shell. The hot-water outlet is covered by a hood and vented to the steam space. This is to prevent the entrance to the pump section of any light particles which might float on the surface of the water. Each section of the heater is provided with a blowoff connection at the bottom of the cylinder. This type of heater is built in sizes up to and including 12,000 hp.

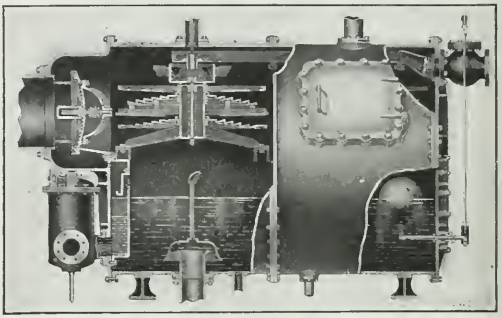


FIG. 9. SEMI-SECTION OF HORIZONTAL HEATER

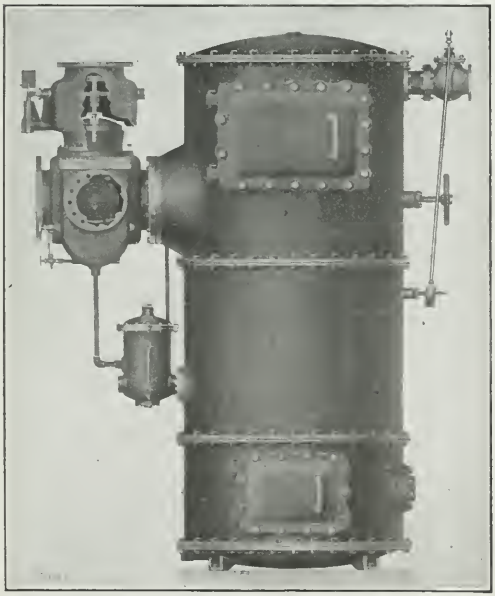


FIG. 8. TEE-VALVE SEPARATOR AND BACK-PRESSURE VALVE ATTACHED TO HEATER

Fig. 10 shows one method of supporting the heater, also that of attaching the cutoff valve and overflow trap.

A feature shown in the horizontal cylindrical heater, which is built for large capacities only, not found in those already described, is that instead of controlling the supply water by one large valve, several valves are used. These smaller valves are actuated by floats placed in outside float boxes, where they are not affected by the pulsation of the steam in the heater.

As shown in Fig. 11, the water enters in front of the central valve and is distributed in equal quantities to the three valves. As the capacity of each spray box and its pan system is equal to the capacity of the valve, it does not matter so far as the final temperature of the water is concerned, whether it is distributed to the dif-

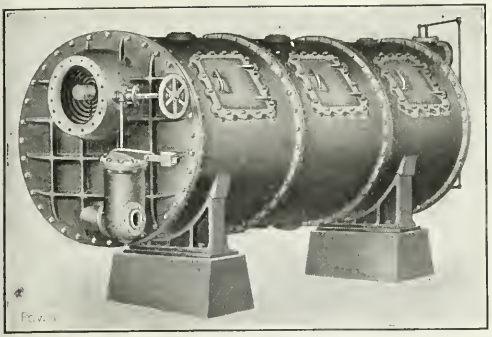


Fig. 10. Heater and Cradles

ferent system pans uniformly or not. By the use of a number of small valves, the supply of water is more uniformly in proportion to the demand than it would be if one large valve were used for the same total capacity.

It is necessary for a valve to accumulate energy sufficient to overcome the friction on the connections between the float valves and the valve combined with the inertia of the valve parts, etc., before it begins to move the valve. Consequently, the control of the water is much more sluggish when using a large float-operated valve than when using a number of small ones. Multiple valves also tend to give a more constant water level, thereby avoiding a sudden rush of cold water into the heater at times when there is not a sufficient amount of steam to heat it. This type of heater is made in sizes from 15,000 to 50,000-hp. capacity.

At times it is desirable to connect up two or more heaters in multiple, and when so doing, it is necessary that the proper proportion of steam be supplied to all of the heaters, and that equal water levels be maintained. This method of connection is illustrated in Fig. 12, where two heaters are mounted in line and the exhaust nozzles connected to the inlet nozzles in such a way that the supply of steam can be controlled by the cutoff valve within the heaters. In plants depending upon auxiliary exhaust steam for heating the feed water, it is necessary at times to supply the heater with live steam.

This is accomplished by placing within the exhaust connection at *D*, a tee branch connected to the live steam supply. As the tee discharges the live steam directly in line with the entrance to the heater, it acts as an injector in increasing the velocity of the entering exhaust steam.

Referring to Fig. 12, *E* is a junction box, *F* is the pump suction outlet, and *GG* are check valves opening inward. The float-control valves are actuated by the variation of the water levels within the two heaters. If for any reason the level in one heater should drop below that in the other, the difference in heads prevents the check valve controlling the outlet of the water in the low heater from opening, and remains in this condition until the water levels in both are equal. In such a case the water should flow at a uniform rate from both heaters into the junction box, and from there to the pump. The main inlet *H* takes the supply from the hotwell. Back of the nozzle *H* is a valve controlled by the float in the

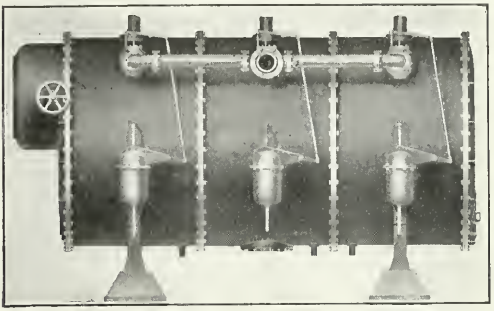


Fig. 11. Triple Inlet Valves

float-box *J*. Should the supply of water from the hotwell be insufficient, the water in both heaters falling to the same level, causes the floats in the float-box *J* to drop and open the valve *K*, admitting raw water. The advantages of connecting two heaters in this manner are that the piping is simplified, that the cost of installation is reduced, an equal water level maintained in the heaters and the proper amount of steam can be supplied to each heater.

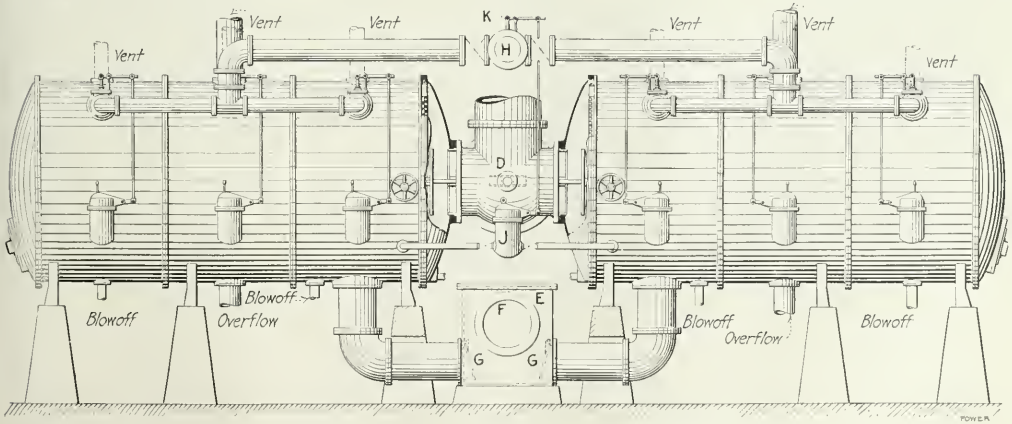


Fig. 12. Heaters Connected in Multiple

Damage by Water in Engine Cylinders

SYNOPSIS—It was found by actual experiment, that due to a relatively short period of admission as compared with the period of exhaust, and to the exhaust ports being larger than the inlet ports, all the water passed out of the cylinder without doing any damage. At light load, however, water might be drawn back into the cylinder from the exhaust pipe and cause damage.

In POWER, June 25, 1912, was published an article explaining how the low-pressure cylinders of compound engines are wrecked by water which accumulates in the receiver and is swept into the low-pressure cylinder. This explanation was questioned by H. Bollinckx, the eminent Belgian engine builder (see July 30, p. 164) "because the admission being only 0.3 of the stroke, the water cannot enter except during this period, but it has at least 0.8 of the stroke to get out of the cylinder. How, therefore, can it stay there to make trouble on the return stroke?"

M. Bollinckx, in order to satisfy himself and others of the soundness of his position, undertook a series of experiments to ascertain if it were possible to wreck an engine in this way. The engine used is shown in cross-section in Fig. 1. The diameter of the cylinder was 13.75 in., the stroke 27.5 in., the steam pressure 110 lb., and the rated capacity 140 hp. at 158 r.p.m. The distribution of the steam was by means of horizontal piston valves controlled by a cutoff mechanism for the admission and a positive drive for the exhaust. The governor controlled the admission up to 55 per cent. of the stroke, release taking place at 90 per cent., the valves closing for compression when the return stroke was 75 per cent. completed. The clearances were about 3 per cent., and both the barrel and the heads were jacketed by the live steam. The tests were made in the presence of MM. Vincotte and Dubois, directors of the Association *pour la Surveillance des Chandieres a Vapeur.*

In order to allow the ready escape of the water taken into the cylinder, the exhaust pipe of 6.7-in. diameter, was installed with a considerable pitch away from the engine and discharged into the atmosphere. Precautions were taken to limit the amount of damage that might be produced. The engine was run single-acting, the head of the operating end held by only three bolts, and an abutment provided to take care of it should it be blown off. The engine was belted to the shafting of the shop which was run by a much more powerful engine, so that its speed was held at that determined by the shafting regardless of the point of cutoff, which could be adjusted by hand. Three boilers were used in connection with the test, two to supply the engine with steam and one at a higher pressure, from which water was drawn for injection into the incoming steam.

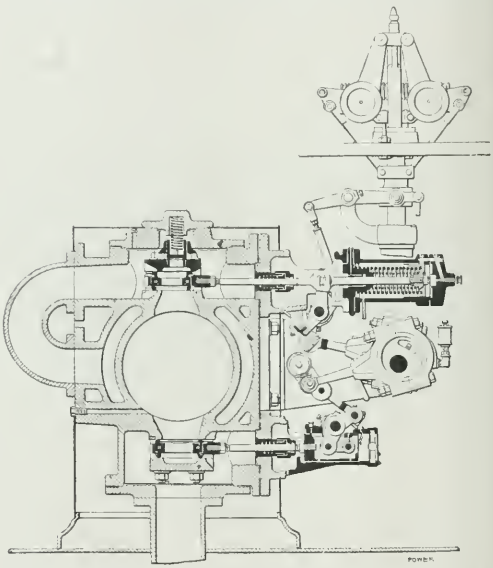
The steam main was 4.35 in. in diameter and 33.8 ft. long. One valve was provided near the boilers, and another near the cylinder of the engine, by which means it was possible to operate the machine from a distance when necessary.

The tests were divided into three series, in the first of which water was pumped into the steam main by a pump 2.75x4.5 in. running at 200 r.p.m.

For the first run the machine was started with a very early cutoff but carried at speed by the belt. The pump was started and discharged its water into the steam main and after passing through the jackets the admission valve and the cylinder itself, it was voided continuously by the exhaust pipe without having produced any damage.

For the second run the degree of admission was augmented slowly and progressively, while the pump continued to discharge water into the steam pipe. The results were the same as in the first test.

For the third run the belt was removed, in which case the engine naturally speeded up as it was given steam



SECTION THROUGH ENGINE UPON WHICH TEST WAS MADE

and as the degree of admission was increased. But even in this case there was not the least shock although the pump was discharging the water continuously.

The second series of tests was made by installing in the steam pipe near the engine a pocket having a volume of approximately 50 quarts, connected by a pipe with the water portion of one of the boilers. This boiler was run at a higher pressure than that supplying the engine, so that by opening the valve in the connecting pipe its water could be discharged into the incoming steam at any rate desired. A water gage in the pocket permitted the movement of water in the pipe to be seen.

In the first run with this arrangement the valve was opened so as to entirely fill the pocket with water. The result was that it came through the engine without damage but in gulps instead of continuously as when fed regularly by the pump. The alternating movement of the water in the pocket was visible in the gage glass. The valve was then opened so as to fill the pocket only partly full. The water came out of the exhaust pipes still in gulps but in lesser volume.

In the next experiment the valve was opened as rapidly as possible to such an extent that the steam pipe was entirely filled with water, as well as the steam jacket. The water came through the engine all right but the first slug was thrown a distance of some 65 ft., and at the same moment there was a shock in the pipe accompanied by the rupture of one of the joints. The pipes separated some ten inches and shortly after another slug of water came along and was discharged through this opening. The exhaust pipe was then repaired and the experiment repeated when the water escaped from the exhaust pipe in successive slugs. The engine was run with various degrees of cutoff and suffered not the slightest damage.

A third series of experiments was made without the jacket. With the engine in this condition all sorts of experiments were made, the steam pipe was filled with water more or less completely, and the machine was run fast and slow with short and long cutoff, but always passed the water without harm.

The conclusion at which the experimenters arrived was that all water which enters a cylinder of a steam engine during the admission is discharged during the exhaust stroke without occasioning any injury to the cylinder regardless of the quantity of the entering water or the load of the machine. This conclusion entails the supposition that the exhaust valves are placed in the bottom of the cylinder.

This is explained by the fact that the admission rarely lasts more than one-half stroke while the exhaust continues during almost the entire return stroke, and the exhaust passages are larger than the steam passages.

It might be suggested that the water would enter the cylinder faster than it would discharge because it enters under the difference in pressure between the interior of the cylinder and the boiler. As a matter of fact, however, at the instant of opening of the admission valve, this difference in pressure is not very great because of the pressure in the cylinder at the end of the compression. The discharge of water from the cylinder is favored by the difference in pressure between the interior of the cylinder and the exhaust pipe, and it should be remarked that the pressure is small for a light load, that is to say for early cutoff, but the quantity of water taken in is also small in this case. The experimenters enumerate the following conclusions:

1. Single-Cylinder Non-Condensing Engines—No damage from water can result if the exhaust pipe is well drained. If water remains in the pipe it will return to the cylinder, especially when the engine is running light and the pressure of the steam at the end of the stroke is less than that in the exhaust pipe.

Precaution—Place at the foot of the exhaust pipe a large pocket, in which the water may accumulate and be careful to see that it is kept empty by a trap or otherwise.

In small installations the exhaust steam from the engine is used to heat the feed water. This process is evidently economical but to avoid accidents to the engine therefrom it is indispensable that the heater be well designed.

2. Single-Cylinder Condensing Engines—Two cases are to be considered, engines with a condenser in tandem and engines with the condenser below.

In the first case the water can accumulate in the pipe between the condenser and the cylinder because this pipe is closed at both ends and forms a pocket. The water brought in with the steam and which accumulates in this pocket if precautions are not taken against it, may be drawn into the cylinder and occasion a water shock. This accident is likely to happen at the time when the engine is being started up or when the load is very much diminished. It is the practice of the Bollinckx shops to place a steam loop upon this pocket, in order to keep it continually empty.

A water shock may happen to this sort of an engine from a defect in the air pump or through mismanagement, such as neglect to close the injection. The precautions recommended are to carefully drain the pipe and to provide a vacuum breaker.

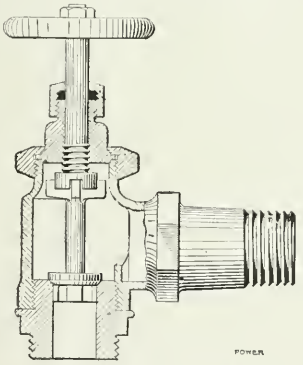
For compound condensing machines, damage by water may be suffered in the high-pressure cylinder by reason of insufficient drainage for the receiver, and every precaution should be taken to see that it is well drained.

Although it is true that water entering by the steam pipe will not produce a damaging shock in the cylinder, it is well that the pipe connecting the engine with the boiler be provided with well drained separators.

Osman Regrinding and Pressure-Equalizing Boiler Check Valve

This valve consists of a slotted head made solid with the valve stem. The slot in the head drops automatically over the projection of the valve body. On screwing out the valve stem, the valve can lift from its seat.

The seat can be reground by bringing the clutch head



Regrinding Check Valve

into action on the valve wings, and screwing in on the valve stem until the disk and seat are in contact, after applying to the valve seat a small amount of emery or ground glass. This operation can be accomplished without removing the valve body or any parts except to momentarily loosen the combination nipple and seat.

The valve, which is made by Gustav A. Osman, Decorah, Iowa, has a combination nipple and seat, which is screwed into the body, thus permitting of removing the seat for repair or examination.

The bridge construction at the port entrance of the stem to the valve chamber equalizes the distribution of steam pressure under the disk, thus preventing oscillation of the disk and eliminating the tendency of excessive wear on the side of the disk nearest to the port entrance of the stem to the valve chamber.

New Manifold and Mixer for CO_2 Recorders

By Morgan B. Smith

SYNOPSIS—One CO_2 recorder will serve satisfactorily four boilers if the gases are thoroughly mixed in the devices described herewith.

In a great many boiler stations the need of a CO_2 recorder is felt, but considerable hesitancy is almost always shown to purchase a single recorder where there are more than one or two boilers. As a matter of fact no such hesitancy should be shown, for it is a proven fact that a single recorder operating on as many as four boilers is a good investment, providing the results are followed up with the firemen. Of course, one recorder for each boiler is the ideal installation, but with a proper mixing of the gases from two to four boilers much valuable data may be obtained.

In a number of plants with which the writer is familiar, it is the custom to hitch up four boilers with each recorder, sending the combined gases, after thorough

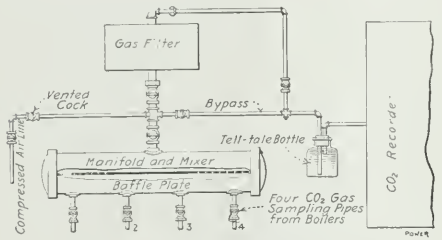


Fig. 1. Connections to Manifold Mixer

mixing, to the recorder, which then analyzes the gases for CO_2, and so gives a measure of the combined efficiency of the four boilers.

In these same plants it is also the custom to send the gases from one boiler to the recorder for periods of from two to seven days in order to get a general average of the performance of the single boiler. By switching from one boiler to another it is possible to keep very close record on the individual efficiency of single boilers in a large plant with only one recorder to each four boilers.

The new manifold is in reality a combined manifold and mixer. The manifold is not as efficient a mixer as the mixer proper but is especially useful where the recorder suction is somewhat weak owing to lack of head in the water supply or for other reasons is unable to overcome the back pressure imposed upon the system by such a device as the mixer proper.

Fig. 1 shows the manifold, as now installed in several power stations in the State of Michigan, together with the necessary connections, etc. The manifold proper consists of a length of 2½-in. iron pipe 18 in. long fitted with gas-tight caps at each end. The gas sampling pipes from the boilers, four to a manifold, enter the lower side and are spaced equidistant from each other. These sampling pipes are ¾ in. in diameter and are fitted with asbestos-packed cocks.

Within the manifold is placed a baffle plate of flat iron perforated at each end with a single row of $\frac{3}{16}$-in. holes, leaving a strip of solid metal at the center. This piece is 18 in. long and lies within the larger pipe in a horizontal position. Its width is 2¼ in., so that it lies a little below center in the manifold.

As apparent in the sketch gases from boilers 2 and 3 are thrown to the ends and are forced to mix with the gases from boilers 1 and 4, passing upwards then through the holes in the baffle plate into the large space above the baffle plate, from which the exit pipe carries the combined and mixed gases to the gas filter above.

Between the manifold and the filter is placed a cross fitting with a. p. cocks on three legs, so that the filter may be bypassed when necessary and so that the gas sampling lines from the boilers may be blown out with compressed air at regular intervals.

At the lower side of the cross shown at the junction of the regular gas line after the filter and the bypass, is shown a plug, which may be removed readily, and the whole line cleaned. This is also a handy place to attach the sampling tube of the Orsat CO_2 analyzer when it is thought necessary to check the recorder.

In the compressed-air line, by means of which the whole system of sampling pipes and manifold may be blown out at regular intervals, there is a vented a. p. cock between the ordinary a. p. cock and the line between the manifold and the filter. This is simply a precautionary feature serving to protect the gases passing between the manifold and the filter into the recorder from dilution with air from the compressed air line. Needless to say this vent cock is faced in such a manner as to take care of any leakage from the air line.

It is readily seen, by reference to Fig. 1, that any one or all of the gas lines from the boilers may be blown out whenever desired and that gases from one or more of the boilers may be sent through the manifold mixer and analyzed in the recorder.

Throughout only asbestos-packed cocks have been shown, no valves whatever, as it has been found by repeated tests that valves are not as well suited to such utilities as cocks. Only such cocks should be used as are reliable, for any leaks past these cocks will be noted by the recorder and wrongly charged up against the combustion.

The ordinary tell-tale bottle shown just ahead of the recorder needs no comment beyond stating that it is used merely to show the rate of gas-aspiration through the manifold and to detect stoppage in the gas lines. Only one is shown, there being another such bottle connected in parallel with the one shown, which acts as a seal so long as the sampling lines are open, but which immediately blows when a stoppage occurs. The filter is provided with unions above and below so that it may be easily removed for cleaning and repacking.

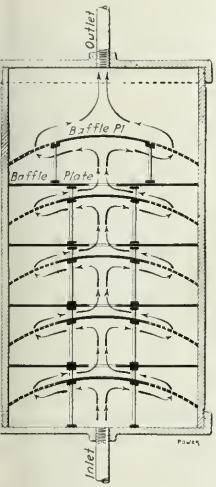
The mixer is more complicated than the manifold mixer just described, but gives better mixing, and, where the suction provided by the recorder is sufficiently strong to overcome the added back pressure on the system, is to be preferred in many ways to the manifold mixer.

The principle involved is that of the gas scrubber, inasmuch as the gases, rising through the mixer, are forced back and forth from the center to the sides and back to the center, etc., by means of baffle plates. These baffle plates are perforated with many ⅛-in. holes concentrically, leaving a solid circular area at the center

out 1½ in. in diameter. The number of baffle plates the mixer may be varied according to the amount of as passing, the ordinary arrangement for gases from ur boilers being from four to six baffles.

The body of the mixer consists of a piece of 4-in. pe about 10 in. long fitted with caps at each end rough which pass the inlet and outlet pipes. The ffles are so built that they support each other and e readily removable for cleaning from time to time. ig. 2 shows the general design of the mixer.

The baffle plates may be easily made from sheet brass galvanized iron. They are then fitted with the legs hich also act as spacers. All the baffle plates may be ldered together as a unit or in pairs consisting of one at baffle and one curved baffle. They should be so tted that they make a fairly tight joint with the inner alls of the containing pipe, but must be readily re-oved for cleaning from time to time. It is necessary to use a manifold between this mixer and the boilers so as to combine the gases before entering the mixer. It has been found that this type of mixer gives excellent results, the only feature not always feasible being the added back pressure on the system.



IG. 2. GENERAL DESIGN OF MIXER

The foregoing descriptions are given in the hope that they may be of value to plant operators who are hesitating with regard to the advisability of purchasing only one recorder for their plant when they feel that a larger number is really imperative. The writer can assure such operators that very good results may be gotten from one recorder to each four boilers if the gases are properly ixed before entering the recorder.

It is hardly necessary to make note of the fact that he rates of aspiration of the gases from the several oilers must be nearly the same in order that the result-nt mixture of gases may be an average from the several oilers. A tell-tale bottle placed in each sampling line etween the boiler and the manifold or mixer will tell a glance the rate of aspiration by the number of ubbles observed per minute.

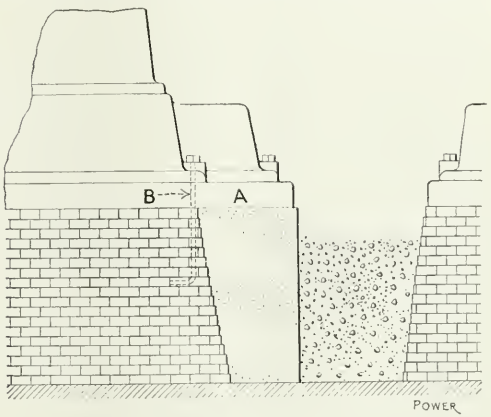
Periodical and regular checking of the recorder and e piping by means of the ordinary Orsat analyzer or milar device is important. Unless one knows that the ping is airtight and that the recorder is actually giv-g correct results, within the limits of such apparatus, l precautions as to correct sampling and mixing are eless and results valueless.

The above-described manifold mixer was designed by . G. Connelly, chief engineer of the Rapid Railway o.'s power station at New Baltimore, Mich., for use th the recorders at that station, and has been in service sufficient time to have proven its adaptability and value for such a utility. Some modifications in the original design were made by H. L. Scheibner, assistant combustion engineer with the Detroit United Lines, of which the Rapid Railway Co. is a part.

Building an Addition to a Foundation

BY W. H. WAKEMAN

The designing engineer of a certain steam plant laid out two foundations for two direct-connected units which were properly laid down, and foundation bolts were placed



HOW THE FOUNDATION WAS EXTENDED

in both foundations, but only one was utilized at the time. After several years more current was wanted, and a different unit was purchased which required a larger foundation, as shown at *A* in the illustration.

The cap on this foundation consisted of a granite block about 12 in. thick, which required additions at one end and side. Earth was removed from between the two original foundations and the space filled with a mixture of crushed stone, cement and sand, which stood for several weeks before the new engine was started. An excavation was also made at the end of the old foundation and the space filled with a concrete mixture.

Extensions for the capstone were made of granite blocks and accurately fitted, care being taken to have them firmly imbedded in the cement. The top of the foundation addition was left rough to afford a good hold for the fresh cement, this method of construction offering less chance for settling. The original foundation was eight years old at this time, and having become very hard, would neither shrink nor settle, although the addition did before the granite cap was laid.

Some of the original foundation bolts were utilized, but four new ones were put in, three of which came in the edge of the old foundation as shown at *B*. They were cemented in place so that it is impossible to pull them out by screwing down the nuts. The other anchor bolt was fitted with a square head and large washer and imbedded in the concrete.

This unit has been in service for about two years, and cracks have developed between the main capstone and the additions, thus showing the benefit from giving careful attention to details.

Revelations of Some Damaged Boilers*

Altogether eighteen cases of accidents were taken up, five of which were fully investigated, as follows:

A. A lower shell plate of a double-flue boiler built in 1892 for seven atmospheres (above atmospheric) pressure, with a heating surface of 979 sq.ft., after being started up for three hours on blast-furnace gas and under three atmospheres pressure, was ruptured in the fourth girth seam. The crack extended over eight rivet holes and ran into the solid plate, so that the boiler was emptied.

The investigation showed that the material cannot be pronounced inadequate, but that the rivet holes were punched. It is to be assumed that fine cracks were thus produced and gradually increased during service, finally leading to a complete break. Such fine cracks were noticed extending from the parts distorted by punching.

B. The second case was that of a front head of an eccentric corrugated flue boiler of 862 sq.ft. heating surface, built in 1902 for 12 atmospheres pressure. After renewing the first flue section, which had been bent somewhat by use of oil and grease and much bent by the hydraulic test which followed, a crack in the round corner at the edge of the flue was observed at the time of cleaning. This crack was almost through and extended over half of the head.

The neighboring parts were covered with numerous fine parallel cracks. It can well be assumed that the main crack was produced by extension and running together of such originally small ones. Nothing could be learned as to their cause. Perhaps very fine, unnoticed cracks were caused by the flanging of the head. Perhaps, also, a heavy stress on the head was produced by the bending of the bagged flue. The material tests all gave satisfactory results.

C. The third case concerned a shell plate from the last belt of a double-flue boiler of 915 sq.ft. heating surface built in 1908 for 8 atmospheres pressure. During cleaning it was noticed that water leaked from a crack. The test piece submitted was a part of the shell plate.

The belt in question lay on a baffle of the setting and showed cracks extending through the part supported near the girth seam, and also strong corrosion on the outside. By the various etching tests and photomicrographs it was perceived that the crack followed the edges of the ferrite grains, whence it is judged that the cracking was caused by strong alternate stresses upon the plate. This assumption is strengthened by the fact that the feed pipe ended just over the damaged place. The cracks are, therefore, very probably due to the circumstance that, in cleaning, cold water was let upon the not sufficiently cool plates. The composition of the material was shown by the tests to be normal.

D. The fourth case had to do with three shell plates of a double-flue boiler having 646 sq.ft. of heating surface, which was built in 1894 for six atmospheres pressure. At the time of a regular hydraulic test, leaks were found in the girth seams. On calking these places, a piece about four inches long broke out of the edge. The rivets there were then removed and the piece chiseled out. Various cracks were now seen running from hole to hole of the seam and several cracks in the edges of the holes. After repairs, and during the hydraulic test, there occurred, at another girth-seam rivet hole, hair cracks which hardly were moistened. After this piece also had been cut out several cracks appeared not only in it, but also in the underlying plate.

Investigation shows that the rivet holes had been punched. It was determined also that the sheet was so bent that the punching burr lay outward. Thereby were produced, from the start, fine hair cracks extending from the rivet holes.

Ball-pressure tests of the material showed a considerably greater hardness at the edges of the rivet holes than in the other parts of the sheet, the hardness figures being 160 to 200 against 120 to 140. A bending test embracing two rivet-hole edges resulted in a smooth break at these edges. The sheet was, therefore, very brittle in the vicinity of the holes. This brittleness must have been caused at the time of riveting, perhaps by the heavy calking of the rivet heads. Several unfavorable circumstances have, therefore, coöperated here to form the cracks. In addition came a not altogether proper method of blowing off the boiler in shutting down, for the too sudden cooling produced strains. The percentage of oxygen, sulphur and calcium was found to be somewhat higher than is good practice today for boiler plates. Notwithstanding, the material, according to the other tests, could not be pronounced unsuitable.

E. The last case was that of three tubes in a water-tube boiler of 3229 sq.ft. heating surface, built in 1911 for 13 atmospheres pressure. It had been in service for 45½ shifts when a water tube of the lowest row ruptured for 10 in. The ruptured bulge was on the bottom and the tube was bent upward by the reaction. Several other tubes were badly bagged.

Right after the accident, it was determined that the metal of the ruptured tube at the place of the crack was not drawn so thin as elsewhere. In the back part of the tube was found thin scale; in the rear header of the tubes was a layer of scale pieces two inches deep.

By microscopic investigation it was found that at the bagged places a strong decarbonization and coarsening of the structure had taken place; the size of grain was six times as great as in the immediately neighboring parts of the tube, therefore, a sharp local overheating had occurred, and this had caused the tube to burst.

The 18 cases of accident submitted from September, 1907, to the beginning of 1912 occurred in 16 instances with stationary steam boilers, in one with a locomobile boiler and in another with a steam drum or tank. In the 17 boiler accidents the material was mild steel while the drum was made of wrought iron.

If the cases be classified according to the causes of the accidents, as they appeared upon the tests, in only two cases must the blame be charged to the material alone, while in a third case other conditions were superadded. In three more cases the cause of the disasters was faulty workmanship; a water tube called seamless proved to be badly welded and twice old welded cracks broke open again. In six cases the punching of the rivet holes is accepted as the cause, in another case faulty design—an inadequately stayed head. Too quick shutting down and introducing cold water into the insufficiently cooled boiler led to two disasters. In three more instances water tubes were burst by scale and overload.

*Report presented by Chief Engineer Bütow, for the committee on testing damaged boiler materials, to the Munich convention of the International Association of Steam Boiler Inspection Societies, June, 1912. Translated from "Glückauf," Mar. 1, 1913.

GAS POWER DEPARTMENT

Tests on Small Gasoline Engines

By F. M. and E. A. White

Since the commercial development of the internal-combustion engine, many experiments have been conducted on the larger types of engines for various purposes. The small-farm engine is a more recent development, but is now attracting the attention of people who formerly thought this a too elementary field for their endeavors. The results of the Winnipeg motor contest have brought about increasing interest in the application of power to the large farms of the Western states, but here again they have ignored the small stationary and semi-portable engines. As yet there is little knowledge in regard to the performance of the smaller types. This work was, therefore, undertaken to determine the fuel consumption in pounds per horsepower-hour for varying loads of the small (3- to 10-hp.) internal-combustion engine using gasoline as fuel.

For this work three general classes were selected, ranging in power from 3 to 4½, 5 to 7, and 8 to 10 hp. These, for convenience, were classified as 3-, 6- and 10-hp. sizes. Twelve engines were used, four representing each of the three general classes. With one exception, one engine of each class was obtained from the same manufacturer, and each engine was tested under no load, one-quarter, one-half, three-quarters and full load.

Description of Engines

Table I gives a brief description of the engines used in the tests which are numbered from 1 to 12.

The gasoline used had a specific gravity of 0.7386 (Baumé, 59.55) and contained 20,800 B.t.u. per lb.

Methods of Conducting Tests

The prony brake was used to apply the various loads and in order to obtain the quarter, half and three-quarter loads, preliminary tests were first conducted in order to find the maximum capacities of the engines. As the speed of an engine increases, with the same setting of the governor, under the lighter loads the resulting horsepower is slightly more than quarter, half or three-quarters of the maximum horsepower; in these tests the governor was not changed except on engines Nos. 2 and 3. The rated horsepower of the engine was not considered in determining the maximum load the engine could carry, as all companies manufacturing engines allow for 10 to 25 per cent. over the rated horsepower, and the results secured bear out this fact.

TABLE II TEST DATA

Engine No.	Average R.p.m.	Brake Hp.	Lb. of Fuel per B.hp.-hr.	Pints of Fuel per B.hp.-hr.	Cost of Fuel per B.hp.-hr., cents	Piston Speed in Ft. per Min.
1	474		3.06			553
	464	1 33	1.56	2 03	0.04	541
	461	2 63	1 11	1.44	0.029	538
	455	3 90	0 87	1 13	0.023	530
	441	5 09	0 95	1 23	0 025	514
2	334		2 06			556
	341	1 78	1 07	1.39	0.028	568
	338	3 54	0.81	1 05	0 021	563
	333	5 23	0 72	0.94	0.019	555
	331	6 93	0 65	0 84	0.017	552
	334	7 63	0 71	0.92	0 018	556
3	326		3 52			597
	319	2 91	1 01		0 026	584
	313	5 72	0 75		0 019	564
	311	8.52	0 70		0.018	560
	319	11 65	0 62		0 016	584
4	467		1 06			467
	471	1 01	1 32	1 71	0 024	471
	462	1 97	0 98	1 27	0 025	462
	463	2 98	0.85	1 10	0.022	463
	466	3.99	0 98	1 27	0.025	466
5	374		2 72			560
	378	1 84	0.98	1 27	0.025	566
	374	3 63	0.82	1 06	0.021	560
	366	5 35	0 79	1 03	0.020	548
	346	6 72	0 96	1 25	0.025	518
6	330		2 23			550
	361	2 73	0.69	0 90	0 018	601
	359	5.24	0.70	0.91	0.018	598
	356	8.07	0.72	0.94	0.019	593
	355	10 33	0.67	0 87	0 017	591
7	429		0.97			500
	467	1 00	1.09	1 42	0 028	544
	458	1.96	0.89	1 16	0.023	534
	453	2 91	0.81	1 05	0.021	528
	436	3.74	0.99	1 29	0 026	504
8	427		1.52			534
	432	1 73	0.88	1 14	0.023	540
	423	3 38	0.70	0 91	0 018	528
	417	5 00	0.65	0.85	0 017	521
	402	6 12	0.65	0 85	0.017	502
9	360		2 17			540
	375	2 25	1.15	1 49	0.03	562
	372	4 16	0.88	1 14	0.023	558
	371	6 68	0 78	1 01	0 02	556
	365	8 76	0 74	0 96	0 019	547
10	438		1 77			510
	427	0 73	1 74	2 26	0 045	498
	428	1 47	1.15	1 49	0.030	499
	438	2 26	1 01	1 31	0 026	510
	417	2 50	0.99	1 29	0 026	486
	407	3.26	1 17	1 52	0.030	474
11	353		3 21			500
	350	1 66	1 38	1 79	0 036	495
	343	3.26	1 08	1 40	0 028	486
	339	4 85	0.80	1 16	0 023	480
	339	6 46	0.76	0 99	0 020	480
	362	7.76	0.88	1 14	0 023	512
12	323		6 15			538
	328	2 50	1 64	2.13	0 042	546
	325	4 95	1 02	1.32	0 026	541
	321	7 34	0 85	1 10	0 022	545
	303	9 15	0 92	1 19	0 024	505

TABLE I ENGINE DETAILS

	Engine Number											
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9	No. 10	No. 11	No. 12
Type: Horizontal (H) Vertical (V)	V	H	H	H	H	H	H	H	H	H	H	H
Rated horsepower	3	6	10	3	6	9	3	5	8	3	7	9
Speed, r.p.m.	375	325	325	425	350	325	450	400	350	425	350	325
Size of cylinder, in.	4¼x7	6x9	6¼x11	4¼x6	5⅞x9	7x10	4⅜x7	5x7¼	6x9	4⅛x7	6x8½	7x10
Diameter of intake valve, in.	1½	1¼	2⅜	1¼	2⅛	2⅜	1¼	1¼	2	1¼	1⅞	2
Diameter of exhaust valve, in.	1½	1¼	2⅜	1¼	2⅛	2⅜	1¼	1¼	2	1¼	2	2¼
Compression ratio	4.5	4 45	4 25	4 42	4.13	3.9	4.5	5 46	4 4	4 5	5.54	4 2
Spark advance, deg.	8 25	8 6	20 8	24 6	15.6	20.7	18	16 4	20.1	18	19 6	15.2
Exhaust opens—deg. early	30.4	32 2	26.9	34 6	28	34 8	25 6	32 4	34.8	25	33	20 5
Exhaust closes—deg. late, or on center (C)	11.9	C	C	C	C	C	C	C	C	C	C	C
Ignition—make and break (M & B), jump spark (JS).	M & B	M & B	M & B	M & B	M & B	M & B	J.S.	J.S.	M & B	M & B	M & B	M & B
Ignition source, battery (B), magneto (M)	B	B	B	M	M	M	B	B	B	B	B	B
Carburetor, pump feed (P.F.) gravity feed (GF.) suction feed (SF.)	PF	PF	PF	GF	GF	GF	SF	SF	PF	PF	PF	PF

All the engines were hit-and-miss governed, and all except No. 1 were hopper cooled; No. 1 had a circulating system.

The length of time required for the individual tests varied, with one exception, from two to three hours. The length of time for each test depended upon the time required to bring the fuel consumption approximately constant, this time varying from 15 to 45 min. The tests were, therefore, made of such length as to give two hours of consecutive running under favorable conditions.

Table 2 gives the summaries of the computations of the original data. In securing these summaries, only the last two hours of the individual tests were used.

The cost of fuel per brake horsepower-hour is estimated on the basis of gasoline costing 16c. per gal.

Irregularities in Data

The data given under description for engine No. 1 show that the spark was not advanced as far as in the other engines. This engine also ran above the rated revolutions per minute, which accounts for the relatively large horsepower it developed.

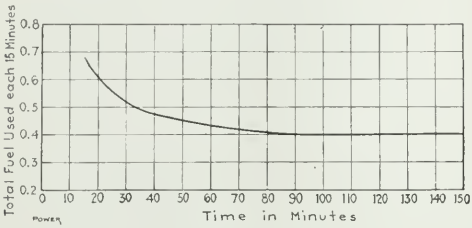


Fig. 1. Showing Time Required for Fuel to Become Constant

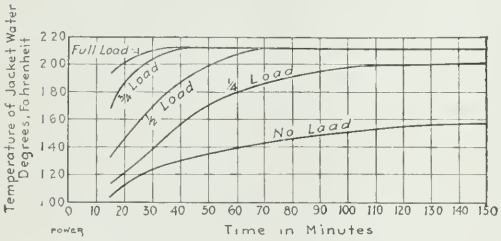


Fig. 2. Showing Time Required for Jacket-Water Temperature to Become Constant

The data given in the fifth test for engine No. 12 represents a one-hour run. In all maximum-load tests, the pounding became so excessive that although four trials were made the test could not be run to completion.

Conclusions

So much time was required for running the individual tests that it is important to find out at what point the fuel consumption becomes constant. The fuel consumption is plotted against time in minutes and is shown in Fig. 1 for the no-load test. This shows that the fuel consumption became practically constant in 90 min.

The fuel consumption for the quarter-load tests showed a tendency to become constant after 75 min., and for one-half load after 60 min.; the fuel consumption for three-quarter load was constant after 45 min., and for the maximum load after 15 min. These results indicate that the lighter the load, the longer it takes the fuel consumption to become constant.

The curves plotted in Fig. 2 show the time required for the temperature of the jacket water for the various loads to become constant. The average temperatures of the jacket water for all the engines under the various loads are taken at fifteen-minute periods.

Table 3 gives a comparison of the time required for the fuel consumption and temperature to become constant for the different loads.

This shows that the fuel consumption becomes constant before the temperature of the jacket water, which would indicate that if some means were employed to

TABLE III

Load	Time at which fuel consumption became constant	Time at which temperature of jacket became constant
None	90 min.	150 min.
¼	90 min.	105 min.
½	60 min.	75 min.
¾	45 min.	45 min.
Maximum	15 min.	45 min.

heat the water in the jacket, the length of the tests could be materially shortened without affecting the accuracy of the data.

Fig. 3 shows the fuel consumption in pounds per horsepower-hour plotted against the different loads for the three general classes of engines. These values were found by taking an average of the separate fuel consumptions for all the engines in the class at the given load.

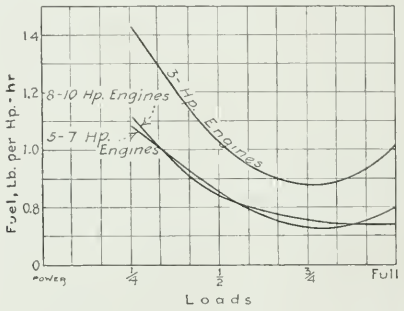


Fig. 3. Fuel Consumption versus Load for Each Class

The curves show that for the 3- and 5- to 7-hp. engines the greatest fuel economy is at the three-quarter load, while for the 8- to 10-hp. engines the greatest economy was secured at the maximum loads. This discrepancy may be explained by the fact that the true maximum loads of the larger engines were not reached in the tests.

It is reasonable to assume that it takes the same amount of fuel to carry the friction load of the engine without regard to the horsepower being developed. If this is the chief factor in determining the fuel economy at different loads then if no other factors enter, the greater the load carried the less will be the fuel used per brake horsepower hour. In order to study this the curves in Fig. 4 were plotted. Here the pounds of fuel per horsepower-hour are obtained for each class of engines by subtracting the total fuel used in the no-load tests from the total fuel consumed in the test for the one-quarter, one-half, three-quarter and maximum loads.

These curves tend to show that up to three-quarter load the friction load of the engine is the chief factor in determining the fuel economy. The 3-hp. and 5- to 7-hp. classes show that from three-quarter to maximum

load other factors enter which cause a very rapid increase in the fuel consumption per horsepower-hour, while the 10-hp. class shows little increase. This would be expected as these larger engines did not reach their maximum horsepower. The smaller engines when running at maximum loads in most cases developed pounding in the cylinder not noticeable at other loads, which point bears out the general conclusions shown from the curves that at maximum loads new factors (probably due to

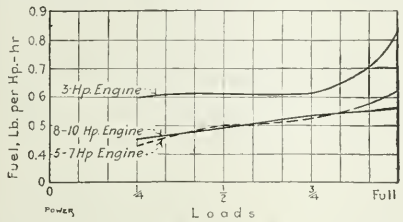


Fig. 4. Total Fuel Minus That at No Load

excessive heat in the cylinder) enter to increase the fuel consumption.

Economical Size for Given Horsepower

The curves in Fig. 5 indicate the proper size of engine to select in so far as fuel consumption is concerned. In these curves, the fuel consumed per horsepower-hour is plotted against the horsepower developed for the three classes of engines, having an average piston-displacement of 55.7, 90.4 and 125.4 ft. per min., which corresponds to the 3-, 6- and 10-hp. classes as previously used. The basis of division according to piston displacement is somewhat nearer an absolute classification than the rated horsepower. These curves show that from 1.7 to 3 hp. the engines having a piston displacement of 90.4 cu.ft. per min. are just as economical as those having a piston displacement of 55.7 cu.ft. per min., and that the larger

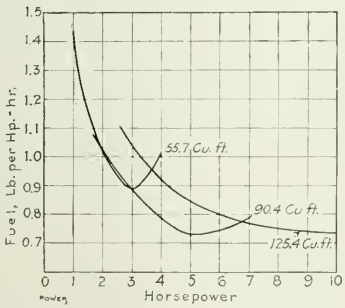


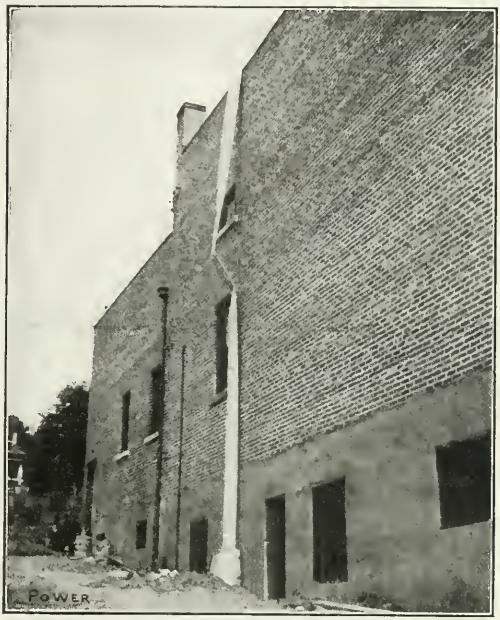
Fig. 5. Fuel Consumption at Different Loads for Different Cylinder Displacements

displacement is more economical from 3 to 4 hp. From 4 to 6.75 hp., the engines having an average displacement of 90.45 cu.ft. per min. are more economical than those having a displacement of 125.4 cu.ft. per min., and from 6.75 to 10 hp. The larger displacement gives the most economical results.

From the foregoing it may be concluded that from 1 to 6.75 hp. the engine having a displacement of 90.4 cu.ft. per min. corresponding to a rated 6-hp. engine is, in so far as economy in fuel consumption is concerned, the most desirable engine. This eliminates those engines having an average piston displacement of 55.7 cu.ft. per min., corresponding to 3 hp. For horsepowers above 6.75, the engines having a piston displacement of 125.4 cu.ft., or the 10-hp. engine, would be the most desirable.

Explosion in Muffling Chamber

A rather unsual accident occurred recently at the Seattle Engineering School, Seattle, Wash. In their gas-engineering laboratory seven or eight gas engines are piped into a common exhaust line, which leads into a muffler just outside the building. This muffler is a concrete chamber five feet wide, nine feet long and four feet



Exhaust Pipe after Explosion

deep. The entire chamber is under ground. At one end of this muffling chamber is a 10-in. galvanized-iron stack about 35 ft. long for carrying off the exhaust gases; this extends to the roof of the laboratory.

At the time of the explosion the only engine running was a 48-hp. four-cylinder Cadillac automobile engine. In testing out the ignition system students tried to run the engine on each cylinder alone, holding down the induction-coil vibrators of three cylinders. This operation was continued for some time before the instructor knew just what was going on, being busy elsewhere. All the gas which was not being burnt was, of course, being exhausted into the muffling chamber. Finally enough had collected there to cause a violent explosion. Although the explosion gave no violent report, it split the walls of the muffling chamber in a number of places and also the concrete pedestal supporting the stack. What happened to the stack is shown by the accompanying illustration.

Geo. W. Muench.

HEATING AND VENTILATION

Operating Economics in Heating Large Factory Buildings

In a paper read before the National District Heating Association at Indianapolis, Edward L. Wilder showed how the Rochester Ry. & Light Co. had been able to effect economy in the operation of the heating systems of two of its large customers. In these particular cases, intermittent heating gave better results than a continuous supply of steam, but the conditions were not equally favorable for both methods. The discussion following the paper favored continuous heating, especially when the outside temperature was below 30 deg. F.

The first case was that of a factory used for the manufacture of automobiles. It is a well constructed brick building, four stories high, and having a total floor area of approximately 60,000 sq.ft. All the heating is done by direct radiation. The installation of a recording thermometer showed that the steam was left on the building all the time, and there was a decided rise in temperature during the night hours. Upon recommendation care was taken to see that at the end of the working day all windows were closed and the steam entirely shut off, turning the steam on in the morning in time to make the factory comfortably warm at 7 o'clock.

Fig. 1 shows a typical week's record of the recording thermometer, taken after the recommendations had been put into effect. It may be noticed that the temperature falls off gradually during the night hours and on Sunday and readily responds when the steam is turned on about 6 o'clock in the morning. The temperatures of 70 deg. and over shown during the afternoons were unnecessarily high for a machine shop. This is accounted for by the fact that the thermometer is placed in the center of the room, and the temperatures near the windows were probably somewhat lower than recorded. In general, the present operation of the system is satisfactory. The temperature record is for the week commencing Saturday, Jan. 18, 1913, and the outside temperatures as recorded by the weather bureau, are as follows:

Fig. 1. Typical Week's Temperature Record

Fig. 3. Temperature Chart Taken before Schedule Was Put in Force

Fig. 4. Chart When Operating on Schedule

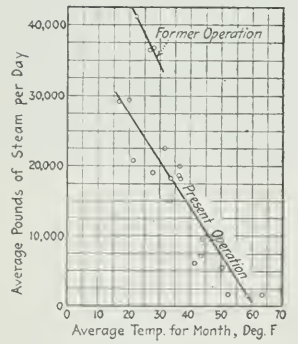


Fig. 2. Economy of Intermittent Service

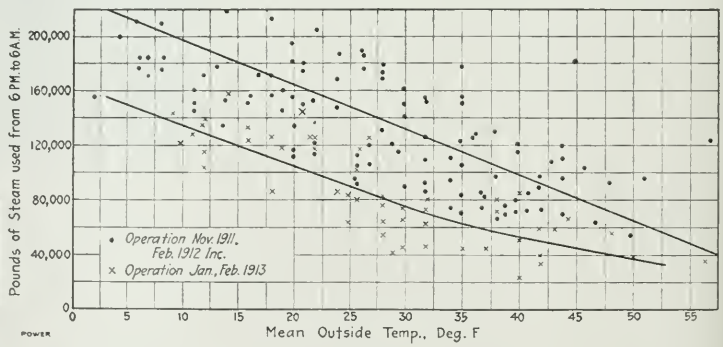


Fig. 5. Steam Used for Night Heating

	Maximum	Minimum	Mean
Saturday	51	30	40
Sunday	35	29	32
Monday	55	33	44
Tuesday	33	23	28
Wednesday	36	25	30
Thursday	47	30	38
Friday	39	31	35

To show the effect on the total steam used for heating, the pounds of steam used per day were averaged for a number of months, and plotted against the average outside temperature for the same months. The results are shown in Fig. 2. The lower curve covers a period of over two years and indicates an average saving of 37 per cent.

The second case was a group of factory buildings with a ground area of approximately 75,000 sq.ft. All the buildings are of good brick construction varying in height from five to seven stories. The heating is mainly by the fan system, and there is provision made for recirculating the air in only one of the buildings, which forms approximately one-quarter of the total heating load. Preliminary investigation showed that the steam was left on the heating coils all the time, that the cold-air openings were not closed at night, and that, if the weather was at all severe, the fans were run continuously. The installation of recording thermometers in several places showed that the night temperatures often ran up to 80 deg. and over. Several tests were run on the operation of the system during the night hours, and the following facts were developed.

With the cold-air openings closed and the steam entirely shut off, the temperature in the buildings dropped at a rate of approximately 1 deg. per hour in severe weather. When the steam was turned on the coils but the fan not started, the natural circulation would hold the temperature approximately constant. When the fans were started up, the temperature of the buildings responded rather slowly.

The conditions of this establishment are entirely different from those in the first one described. In the first factory the work requires considerable muscular exertion, and if the temperature is a little low in the morning, no particular harm is done. In the second case, a great deal of the labor is light bench work, a great many girls are employed in certain departments, and some of the work in progress would be ruined if the temperature were allowed to get too low. It was the opinion of the management that the temperature should not be allowed to get much below 65 deg. at any time, and that 70 deg. was the desirable temperature during the working hours.

Based on the data given above, the following schedule for the operation of the heating system was recommended.

GENERAL INSTRUCTIONS

5:30 p.m. Close cold-air intake, stop all fans, turn off steam from all fan coils.

6 a.m. Open cold-air intakes. Amount of opening to be regulated by condition of temperature and wind pressure outside. If temperature in any building gets below 65 deg., steam must be turned on and fans started in such building immediately.

IF OUTSIDE TEMPERATURE IS ABOVE 45 DEG.

4 a.m. Turn steam on fan coils.

6 a.m. Start fans taking air from basement, except in Building 7.

IF OUTSIDE TEMPERATURE IS BETWEEN 35 AND 45 DEG.

3 a.m. Turn steam on coil fans.

4 a.m. Start fans.

IF OUTSIDE TEMPERATURE IS BETWEEN 25 AND 35 DEG.

6 p.m. Turn steam on coil fans.

3 a.m. Start fans.

IF TEMPERATURE IS BELOW 25 DEG.

6 p.m. Turn steam on coil fans.

1 a.m. Start fans.

Fig. 3 shows a chart from the recording thermometer taken before this schedule was put in force, and Fig. 4 shows a record from the same thermometer afterward. Fig. 3 shows an operation rather better than the average and Fig. 4 shows in a lesser degree the same "sawtooth" effect secured in the first factory described. Following are the outside temperatures for the week of the chart shown in Fig. 4:

	Maximum	Minimum	Mean
Sunday	35	29	32
Monday	55	33	44
Tuesday	33	23	28
Wednesday	36	25	30
Thursday	47	30	38
Friday	39	31	35
Saturday	51	30	40

To determine what economy had been effected, the steam used during the night hours was plotted against the corresponding outside temperature in Fig. 5. The solid dots show the old method of operation, and the crosses show the results obtained after the recommendations were in force. The curves drawn give the average of these points. The total steam used for heating showed an average decrease of 32 per cent.

Loss Caused by Elbows in Air Ducts*

It has been shown by different experimenters that the loss in pressure in heating and ventilating systems through a sharp-turn elbow is the greatest, and that this loss gradually decreases as the radius of curvature of the elbow is increased. In the present paper the results of a series of experiments carried on at the testing plant of the Buffalo Forge Co. are given. Two sets of experiments were carried on: the first to determine the effect obtained by changing the radius of the elbow; the second to study the effect of reducing the throat of the elbow to the theoretical or blast area.

The general arrangement of the apparatus used in making these experiments is shown in Fig. 1. It comprised a blower equipped with an arrangement for varying the air quantity—an air-tight box into which the air

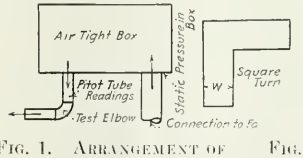


Fig. 1. Arrangement of Testing Apparatus

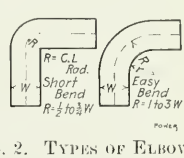


Fig. 2. Types of Elbow Used in Tests

is blown—and an outlet from the box so arranged that the different elbows or fittings may be attached and their effect studied. The discharge outlet was fitted with a short length of pipe three diameters long, and a pitot tube mounted in the center of the pipe one diameter from the outlet. The elbows were attached to the outlet end of this short pipe and another piece of pipe three diameters in length placed on the outlet end of the elbow.

*From a paper read by Frank L. Busey before the American Society of Heating and Ventilating Engineers, July 17-19, Buffalo, N. Y.

In making these experiments the static pressure in the box was accurately measured and by means of a sensitive differential gage attached to a pitot tube in the short outlet pipe the velocity pressure of the air in the outlet was also noted. As different elbows were attached to the outlet pipe, the speed of the fan was increased so as to maintain a constant-pressure reading at the pitot tube. The static pressure in the box increased and the increase noted as a measure of the resistance or pressure loss of the elbows used.

Careful tests were made to determine the coefficient of the short length of pipe attached to the outlet of the box, and 0.825 selected. That is, the actual velocity through the pipe or the effective area of the pipe will be only 82.5 per cent. of that indicated. The velocity head producing the discharge will then be the static pressure reading in the box multiplied by the square of 0.825. Any increase in static pressure due to the addition of an elbow to the outlet expressed as a percentage of the

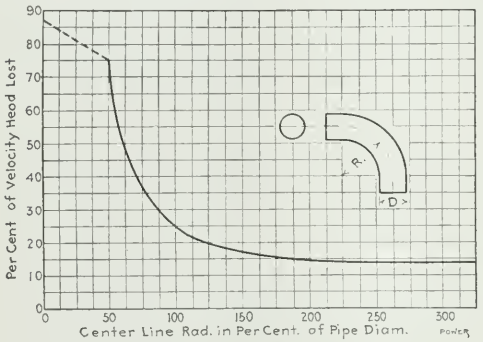


Fig. 3. Pressure Loss in Round Elbows

velocity head as determined in the foregoing gives a direct measure of the pressure loss due to this especial elbow as a percentage of the velocity head. Quite an extensive series of experiments were made with various static pressures and rates of discharge.

Pressure Losses Due to Elbows

The character of the elbows used in these experiments is shown in Fig. 2. They were either round, 12 in. in diameter, or square, 12x12 in. in section, elbows of similar radius of curvature being tested in both the round and square sections. What is here termed a square-turn elbow is shown in Fig. 2 as being actually of a square or two-piece type. The term short-bend elbows is used to designate those elbows having the outer surface rounded off and the inner angle either square or sprung to a very short radius. The easy-bend elbows were those having a center-line radius of from one to three times the pipe width or diameter. Nine elbows, each of the round and square section, were used, as follows:

R = Center-Line Radius In Diameters	R = Center-Line Radius In Inches	r = Throat Radius Inches
0.50	6	0
0.75	9	3
1.00	12	6
1.25	15	9
1.50	18	12
2.00	24	18
2.50	30	24
3.00	36	30

The curves in Figs. 3 and 4, based on actual test results, show respectively the loss by friction through elbows of either round or square section. The loss in per cent. of velocity head is given for elbows of different radii, the center-line radius being expressed as a percentage of the pipe diameter or width.

It may be seen from these diagrams that with $R = 1\frac{1}{2}\ D$, or an inside radius of one diameter, fairly good results may be obtained, without making the elbow unduly long. Practically nothing is gained by making the radius R greater than $2\ D$.

It is also evident from an inspection of these diagrams that if it can possibly be avoided an elbow with R less

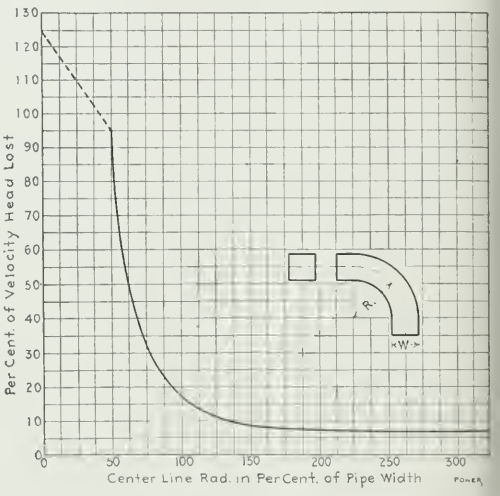


Fig. 4. Pressure Loss in Square Elbows

than one D should not be used. Even with $R = D$ an elbow in a square duct will cause a loss of 17.5 per cent., and in a round duct 25.5 per cent. of the velocity head. In case $R = \frac{1}{2}\ D$ (throat of elbow square, but outer side rounded to a radius of one diameter) the loss in a square duct will be approximately one, and in a round duct three-quarters of the velocity head. The loss indicated on the diagram for $R = 0$, represents tests on elbows of two-piece construction, or with both inside and outside made square.

From the curve for the round ducts it will be seen that with an elbow having $R = \frac{1}{2}\ D$ the loss will be 17 per cent. of the velocity head. If it is considered that one velocity head is lost in 50 diameters of straight pipe, this means that this elbow is equivalent in friction effect to 8.5 diameters of pipe. If the elbow were in a square duct the loss would be equal to 4.5 diameters (or widths) of pipe with a velocity of 2000 ft. per min. through the duct, corresponding to 0.25-in. pressure, or a velocity head of 0.25 in., the foregoing elbow in the round pipe would cause a loss of 0.0425 in. and in the square ducts of 0.0225 in.

For ordinary calculations one easy long-radius elbow in a circular pipe may be considered as equal in friction loss to 10 diameters of straight pipe. The results of the tests to determine the effect of reducing the throat of the elbow to the theoretical or blast area will be given in a later issue.

EDITORIALS

The Hall of Records Test

The test now being conducted at the Hall of Records is attracting wide attention, not only because it is probably the most comprehensive ever undertaken, but also because of the bearing the results are likely to have upon the future policy of the city relating to operation of power plants in public buildings.

Many have criticized the city for entering into partnership with the New York Edison Company in the solution of a problem of this character. While there may have been mitigating circumstances to excuse such a course, from the viewpoint of an outsider the criticisms seem justified. Certainly New York City could afford the costs of such a test and has enough engineering talent in its employ, without taking into its counsels a private party whose interests are decidedly partisan and whose actions are bound to be governed accordingly.

We do not mean to infer that this is likely to have any influence upon the actual test, which, we are satisfied, is being conducted along strictly impartial lines; but it does give the New York Edison Company a large representation in the advisory board which will determine the overhead charges. Judging from past experiences, the representatives of the Edison Company will undoubtedly try very hard to burden the plant with all sorts of fictitious fixed charges, and it behooves the other members of the board to take a determined stand against any such attempts.

If it were a question of shutting down the plant and substituting central-station service, then only fixed charges upon its scrap value should be considered. But where it is desired to arrive at the total cost of producing electrical energy then all the proper charges should be included, but no more.

In the first place the Hall of Records plant cost much more than it should, as a result of which the legitimate fixed charges will necessarily be high. Moreover, the plant is underloaded. In apportioning the fixed charges the electrical load should be charged with only its share of the steam-making equipment in the proportion of its load to the total load on the plant.

No doubt an attempt will be made to charge rent for the floor space occupied by the plant. We do not believe, under the circumstances, such an item should be allowed, but if it is, the rate should be based solely upon what the city could get for this space in the sub-basement were it to rent for storage purposes.

The policy of making public no figures until the test is completed, is commendable. Of course, this does not apply to the New York Edison Company which receives duplicate copies of all data—a privilege to be expected in return for its contribution toward defraying the expenses of the test; but even though the final outcome be unfavorable to its interests, the money will have been well spent in securing complete data which the company may use for reference in other cases that may come up from time to time.

The Smoke Inspector's Tribulations

As noted on another page a fine mess of petty crime has been unearthed in the smoke-inspection department of the City of Chicago through the suspension of nine deputy inspectors and their trial before the city Civil Service Commission.

Chicago's smoke-inspection department is probably more widely and favorably known than any other in the United States. The reasons for this are because it was among the first to be instituted and, principally, because it has accomplished much, both along the line of actual smoke abatement in that city and in solving the engineering problems encountered in attempts to secure smokeless combustion. Almost all cities of any size now have their smoke-abatement departments and the work of educating the plant owner and operator to an appreciation of the advantages, both direct and indirect, of smokeless operation has now progressed very materially.

The present trouble in Chicago, however, serves as a reminder of the generally unpleasant nature of the chief inspector's task.

The tendency of the general public is to fasten the eye of suspicion upon him unless he succeeds, instantly upon appointment to office, in eliminating all smoke within the city gates. The public seldom considers that he has a thousand and one obstacles confronting him, many of which are almost insurmountable. Often, the money appropriated for the use of his department is inadequate and he cannot employ the amount and grade of assistance needed for best results. The secret corruption of his subordinates is another factor that is ever imminent. Imminent because, as yet, it is only the strength of the individual that prevents its development. If the present situation in Chicago is any criterion, the plant owner and operator, principally the owner, we are inclined to believe, from the evidence in hand, consider that bribery is more economical than reasonable effort toward smoke prevention. In reality, it is doubly expensive, because the inefficiency manifested by the presence of smoke endures while the value of the bribe constitutes an added loss.

On the other hand, the plant owner or operator, if he be too shrewd or virtuous to stoop to bribery, is ever ready to believe that the head of the smoke department is a rogue, if he is prosecuted for smoke-ordinance violation. He is convinced that his offence is no more flagrant than that of his neighbor, who has offended unmolested. Occasionally he is correct, if his neighbor happens to be one of the bribe givers. More often, he is mistaken—the offenses of our neighbors loom large compared with our own.

Finally, the head of the smoke department is often the victim of political conspiracy. If the party in power changes he has the prospect of being required to look elsewhere for occupation. Always, he may expect to enjoy the efforts of detractors in the form of disappointed aspirants to his position.

The Penalties of Boiler Mismanagement

The importance of good firing can never be exaggerated in studying steam-plant economy. The evil results of improper fuel handling, of poor water tending and of a parsimonious policy in the boiler-room wage account bring so much discredit upon executive officers responsible for such conditions that a larger knowledge of just what happens when the steam generating end of an installation is neglected is most desirable.

Not many weeks ago a series of tests was made of a 10,000-ton steam turbine passenger vessel guaranteed by the builders to make sixteen knots per hour when operated intelligently on Cumberland coal or its equivalent, with a maximum fuel consumption of seven tons per hour. The boat was equipped with ten water-tube boilers and was propelled by two marine turbines rated at about 4000 horsepower each. She was the product of one of the best American shipyards, and yet she failed to meet the above guarantee on the service trials, although on preliminary trials by her builders she met the requirements in first-class fashion. What was the reason for the trouble?

A careful study of the conditions obtaining on the service trials brought to light an amazing neglect on the part of the vessel's purchasers of the methods of proper steam engineering in the operation of the boat, and in a word, almost every trouble encountered was found to be due to poor firing and associated difficulties. The vessel's builders warned the purchasers that water-tube boilers called for much more skilful firing than the usual Scotch marine boilers, including a more even distribution of coal over a larger grate area and particularly a close control of the water level. The boilers used contained only about one-fourth as much water as the Scotch marine units first suggested. By the use of water-tube outfits about twenty thousand dollars was saved in the construction of the ship, and better deck arrangements and coal distribution of an improved character were secured. The purchasers contended that their engineers were thoroughly alive to the situation and at once set about the service tests.

On the vessel there were three sets of firemen required, with three shifts of water tenders, the watches being four hours in length. The purchasers desired to operate the vessel with a total of twenty-four firemen, or eight per watch, and with one water tender per watch; while the builders maintained that thirty firemen were necessary to operate the ship at its contract speed, and that two water tenders per watch should be provided in view of the type of boilers used and the fact that half the boilers were in one boiler room and half in another. The latter arrangement was utilized on the builders' preliminary trials, when the vessel met her contract requirements, but on the service test only twenty-four firemen and three water tenders were used, with the additional disadvantage that none of the former had had experience in firing water-tube units. This arrangement, instead of providing one fireman per boiler and making four fire doors the number to be cared for by each man, made it necessary for each fireman to serve five doors. The firing in adjacent boilers was thus overlapped, and there was established a sort of dead line in the fire between each man's assigned grate areas which resulted in serious inefficiency of combustion and reduced capacity in steam raising.

The inexperience of the force and its inadequacy in point of numbers led to excessive coal consumption, water going over into the turbines, and to priming. On the builders' tests, when the equipment was given a fair show, the fuel consumption per brake horsepower-hour was about 2.2 pounds, the speed of the vessel being 16.7 knots. On the service trials, when the reduced number of firemen and water tenders was employed, the coal consumption rose to 4.11 pounds per brake horsepower-hour, and the speed of the ship seldom exceeded 14 knots. Instead of maintaining an even water level, there were observed the most serious fluctuations in the height of the water in individual boilers, both above and below normal. No automatic regulators controlling the feed-water supply were installed until a later period. The steam pressure varied all the way from a normal of 250 pounds at the boilers to 180 pounds; the firing was extremely irregular, holes were allowed to accumulate at various points on the grates and the draft was poor as a result. The coal was laid on the fire in lumps and hollows, dead areas were permitted to accumulate on the rear of the grates, and the fuel was not spread as it was fired, but was thrown into the furnaces in bulk. As the steam pressure dropped, strenuous efforts were made to choke the furnaces with enough fuel to overcome the fall.

On account of overfilling the boilers with water, it became necessary many times in the early runs to blow them off, so that more than 300 tons of the fresh water feed supply used in the closed condensing system and boiler tubes was lost in the first run, necessitating pumping salt water into the feed tanks near the end of the test voyage and later requiring the introduction of muddy river water for the same service.

The going over of water to the turbines due to excessive water level slowed down their speed from 10 to 20 revolutions per minute, the water lowering the steam temperature and acting as a mechanical brake in the spaces between the blading. With the introduction of the salt feed and of the muddy river water into the boilers excessive wear almost immediately developed in the turbines and their auxiliary pumps. Priming also occurred at the boilers, and trouble occurred through the seizing of the air pumps, with consequent loss of vacuum and of efficiency. The turbine blades were built of extruded bronze, but were eroded as though they had been subjected to a sand blast. The use of water charged with mud fouled the air-pump buckets and resulted in serious scoring and marring of pistons, rods and valves. Water entering the steam cylinders of the pumps short-stroked these, and the equipment as a whole was damaged to an extent requiring the expenditure of many thousands of dollars in repairs.

Taken as a whole the tests bear eloquent testimony to the need of adequate supervision and discipline in the boiler room, to the importance of maintaining regular conditions in firing and water tending, particularly in the number of men employed, and above all they emphasize the penny-wise-and-pound-foolish economies of cutting down the boiler-room payroll to a point where skilled men cannot be obtained for the difficult and responsible work of firing.

READERS WITH SOMETHING TO SAY

Corliss Valve Trouble

Our 1000-hp. Corliss engine, slowed down, refusing to carry the load. The eccentrics are marked and inspection proved them to be properly adjusted. On again starting, the receiver pressure went considerably above normal, and in turning the regulating rod to reduce it we found it further increased. To reduce it we had to turn the rod in the opposite direction.

This directed our attention to the admission valves of the low-pressure cylinder. The valves are in a vertical position. The setscrew, which prevents the valve stem from turning, was found loose, allowing the rod to turn, which lowered the valve until it took steam over the top. When the valve was raised it closed the ports, shutting off the steam.

The valve was raised and properly set by use of the indicator.

North Adams, Mass. JAMES MITCHELL.

A Few Interesting Kinks

Every engineer knows how bothersome it is to protect blowoff pipes inside the boiler setting. I have found a new way to protect mine. Instead of bothering with cast-iron sleeves that seldom fit or brick covers that split and fall down, to say nothing of filling the space in the combustion chamber, I simply cover the blowoff pipe from the boiler to the wall with ⅞-in. asbestos rope. Then I make a plaster of equal parts of asbestos meal and fire clay and add one pint of fine salt to a 16-quart pail full of the plaster, and add just enough water to make a stiff mass. This is plastered on over the rope with the hands and crowded between the turns of rope.

Perhaps some of the readers of POWER have had occasion to temporarily connect a fire hose to a steam-pipe line at some time or other and found trouble in getting a fitting that would make the connection. I used to have a lot of trouble myself until I found this kink: Take the male-thread end of a discarded length of 2½-in. fire hose and cut or burn off the canvas and rubber. Then find a piece of 2-in. pipe with a thread on one end and file the other up brightly for about 2½ in. of its length and either insert the pipe into the hose coupling and solder it there or do a real good job by tinning the pipe and sweating or brazing it into the hose fitting.

A few weeks ago I had a night fireman who was careless about blowing down the boilers and as a result I found a plugged blowoff pipe, so instead of taking all the joints apart clear back to the boiler, I simply disconnected the pipe back to the blowoff cock, and then, taking the fitting described above, screwed it into the cock and connected a length of hose from it to the fire pump. I then started the fire pump slowly and opened the cock. This quickly removed the scale from the boiler.

Auburn, Mass. W. E. CHANDLER.

Corrosion and Erosion

The writer has, on several occasions, seen articles describing, and illustrations showing, various pump parts badly eaten by the action of the water, the cause of which was almost always attributed to electrolysis.

In a recent article pictures were shown of a pump runner and diffusion vanes which had been badly eaten by the water. It was noted that the motor current consumption increased as the wearing increased, and the supposition was that some of the current leaked out and set up an electrolytic action and so damaged the pump. The water handled by the pump contained some salt and sulphur.

The writer has had some experience with pump failures of this nature and believes that the cause of the damage in this case was not due to electrolysis, but to the combined action of corrosion and erosion, mostly the latter.

Erosion is due to the mechanical action of the water striking continually on a metal surface and its effect is sometimes very rapid. This action must be distinguished from corrosion, which is a purely chemical action. The effects are most marked when operating under high speed or with water containing harmful chemicals or grit.

Experiments have been made with various metals at the concern where I am employed, and the action of water on them has been studied. Cast iron was originally used for making pump runners, but when turbine-driven the pumps proved short-lived when handling even the purest water. For slow-speed, motor-driven pumps, running from 480 to 720 r.p.m., the erosive effect was not nearly so bad.

The practical metals best suited to resist the action of erosion may be listed in the following: Monel metal, hydraulic bronze, acid-resisting bronze, phosphor bronze, chilled cast iron, cast iron and lead.

The action of the water on the metal is both mechanical and chemical. Most of the wear is caused by the action of continuous hammering of the water on the metal. This is also accomplished by more or less chemical action, depending on the character of the water.

Water in striking the metal makes innumerable small holes, giving the metal the appearance of worm-eaten wood. In some cases the erosion was so bad that the metal was similar to chalk or paste in character. The rapidity with which this change takes place is almost unbelievable.

A brass diffusion vane, by mistake, was placed in a pump backwards. The metal in the vane was about ½ in. thick. This was worn through by the action of the water in about 60 hr. This is, of course, much faster than could be produced by chemical action alone. The water velocity leaving the wheel in this case was something like 90 ft. per sec.

Lead is one of the very best metals to resist corrosion, but it is very poor in resisting erosion. One of the necessary qualities to resist erosion is that the metal have a very hard, smooth surface.

Copper is much too soft to resist the eroding action of water traveling at high velocity, but it is very well suited to withstand the eroding action of steam, unless the steam is highly superheated.

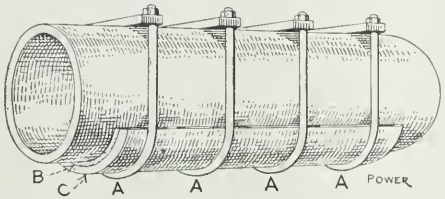
When a pump runner or diffusion vanes become seriously eroded the pump efficiency becomes low and requires more than the normal power to operate it. This would account for an increase in power required and is a more reasonable explanation for the increased power consumption, mentioned, than the supposition that some of the current leaked out and set up an electrolytic action.

HAROLD M. GRAHAM.

Wilkinsburg, Penn.

Stopping a Bad Leak

The 4-in. suction pipe leading from a pond to a circulating pump froze and burst. As there was no union near the fracture, to put in a new length of pipe would mean to take up the pipe from the pond to the fracture.



HOW THE LEAK WAS STOPPED

The illustration shows how it was repaired. *AAAA* are U-bolts, *B* is a gasket and *C* is a piece cut from a pipe of slightly larger diameter than the pipe to be repaired.

EARL PAGETT.

Coffeyville, Kan.

More about Graphite for Boilers

For a period of ten weeks I have been experimenting with graphite as a scale remover, and find that it proves satisfactory in our boilers. As the action of the graphite is very slow, various boiler compounds have been mixed with it, the idea being to soften the scale a little quicker and allow the graphite to get to the plates sooner. After three trials in which careful observations were made, the best results were found to be obtained when using a mixture composed of half a pound of graphite mixed with one pound of soda ash and feeding the mixture at the rate of one pound of mixture to each 20,000 lb. of water. This mixture should, undoubtedly, vary with the nature of the feed water and working conditions, the mixture is fed in along with the feed water and feeds constantly through an ordinary composition feeder, the ash and graphite being first mixed dry and put into the feeder.

On closely examining scale which has come away of its own accord, the surface which has been next to the shell will be seen to be dotted with graphite specks, these will be quite clear under a good glass. It has been our experience that practically no scale forms where the old has come off when graphite has been used.

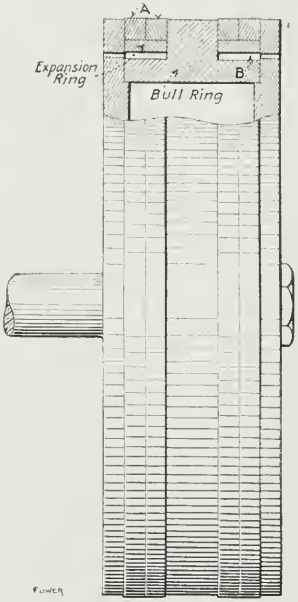
The action of graphite in removing scale is not clear, but it certainly removes the scale, and I am under the impression that if one were to well rub the plates of a new boiler with graphite and water or some other moistening medium, no trouble would be experienced from scale. It would be interesting to all engineers if someone who has a new boiler going in service would try the experiment and publish the results in POWER.

The writer is shortly going to try graphite in one plant that is badly scaled, and as many chemical works and other factories use the water before it comes to this mill, compounds have all failed, the feed not being of the same composition three hours a day. The only way to use this water is to allow the boilers to scale so as to protect the plate from the corrosive water. The scale is now so heavy as to subject the boiler to bagging at high pressures and temperatures.

Rochdale, Eng. E. R. PEARCE.

Steam-Expanded Piston Rings

The accompanying illustration shows a piston with steam-expanded rings which has recently been patented by H. Gulbranson, of Mason City, Iowa. As will be seen, there are two piston rings *A* which fit snugly over



PISTON WITH STEAM-EXPANDED RING

an expansion ring and two of these combinations are slipped over a bull ring which is $\frac{3}{16}$ in. smaller than the bore of the ring, thereby leaving $\frac{3}{16}$ in. space *B* between these two parts. This space is left for the steam to press or expand the piston rings. The steam for this purpose is admitted through a dozen small holes drilled in the follower plate on a circle the same size as the inside of the piston ring.

The question arises as to whether or not these rings will not bind so tightly as to score the cylinder, or to produce so much friction as to cause an excessive amount of oil to be used.

Mason City, Iowa. R. E. SKON.

QUESTIONS BEFORE THE HOUSE

Worthington Rotary Air Pump

Referring to the article by W. Vincent Treeby in our issue of July 22, 1913, we desire to emphasize most emphatically that this hydraulic vacuum pump is not an ejector, although sometimes carelessly so described—doubtless on account of confusion in the writer's mind because of the similarity in form to the ejector. The patent application was made and the patent granted upon this apparatus as a "vacuum pump," and its operation is clearly that of a pump.

While it is impossible for any obstruction to enter the rotor in such a way as to stop its rotation, it is possible by removing the oil cup mounted upon the nozzle head, to secure this shaft and to prevent its rotation, and by doing so, convert the apparatus into a type of ejector, which, however, becomes very inefficient.

It goes without saying that an ejector with fixed throat could be designed which would replace the jet-transforming wheel, but this would be a very different apparatus and would be lacking in the important features of the Worthington hydraulic vacuum pump.

This form of pump is superior in that it uses a simple centrifugal pump and a simple vacuum pump, instead of the complicated pump with many passages ordinarily used for this work. It is possible to place the vacuum pump right at the condenser if so desired. None of the rotors has shown any wear whatever, where the usual type requires constant oversight and replacement. The Worthington pump has a fair range in capacity and is less affected in its operation by air than any of the other types, while its thermal efficiency and its efficiency as an air compressor based upon isothermal compression, practically agree with the best pumps of this type.

GEO. J. FORAN.
HENRY R. WORTHINGTON.

New York City.

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Algae in Water

In the July 1 issue, D. M. Liddell refers to the use of copper sulphate to kill algæ in water and to the probable damage to boilers by copper-sulphate-treated water.

I have had considerable experience with the copper-sulphate treatment of water for eradicating algæ for the past 10 years. We have a private reservoir of about 4,000,000 gallons capacity and have considerable trouble with algæ at times. It used to be so bad that the water stained finished cloth and gave it a rotten-fish smell; for drinking purposes it was no use at all as the smell would make one sick; in the boilers, the organic matter present would cause bad foaming. In 1904, having learned that a department of the Federal Government was experimenting with the use of bluestone as a purifier of water, we obtained all the information necessary for this treatment given in Bulletin No. 64 of the Bureau of Plant Industry, U. S. Department of Agriculture, issued May, 1904, and have used this method with success every year since.

The quantity of copper sulphate required depends on the germs of algæ present in the water, as some germs succumb quicker than others. The most common blue-green algæ, Anabæna *circ.* will all be killed by a solution of 1 in 1,000,000. Anabæna *flos-aqua* succumbs to 1 in 3,000,000. Uroglena, another common type, take 1 in 2,500,000, and the Spirogyra take a solution of 1 in 75,000 to kill them all; the Diatoms generally require a concentration of about 1 in 200,000.

However, it is not necessary to kill all the algæ, and a solution of 1 in 1,000,000 is strong enough to kill all the commoner types and prevent the growth of some of the other types.

For the success of the treatment the copper should be precipitated in the colloidal form, and if the water contains no alkaline salts, or is on the acid side, it will be necessary to add some lime to the water after the copper treatment to cause precipitation of the copper. As a general thing, however, natural waters contain enough lime or magnesia in solution to slowly precipitate the copper and neutralize the sulphuric acid.

The strength of the solution is not anywhere near the danger point of potability, as a man would have to get away with 50 quarts of water a day to produce any ill effects from the chemicals used.

As to the effect on boilers; a 100-hp. boiler working 12 hours a day and using 42,000 lb. of water in that time with a solution of copper sulphate of 1 in 1,000,000 would get 0.042 lb. of copper sulphate into the boiler, or 19 grams; this quantity of copper sulphate would do very little harm, especially as it can easily be neutralized by an equal quantity of soda ash which would precipitate the copper as a mixture of copper carbonate and copper hydrate and the acid would combine with the sodium, forming sodium sulphate, a neutral salt.

However, even if the solution in the reservoir is as strong as 1 in 1,000,000, the water delivered by the piping system will not carry anywhere near that amount of copper sulphate as the greater part of the salt is neutralized and precipitated in the reservoir itself.

When the algæ are killed by the copper, the vegetable matter coagulates and falls to the bottom, carrying most of the copper with it, and three or four days after the treatment, a very delicate chemical test is necessary to find even a trace of copper in the service water.

In our reservoir we used 60 lb. of copper sulphate the first year in one dose and 150 lb. the second year in two treatments. We have used about 100 lb. each year since, but have not found it to be needed this year so far. We have never had any trouble from copper poisoning or any complaints of ill effects and not the slightest sign of copper deposits or corrosion in the boilers or piping. We have always used some form of soda in our boiler feed; usually Tri-Sodium Phosphate, purchased in the open market.

This treatment generally kills most of the bottom-feeding fish, such as suckers, bull heads and eels, and it is necessary to keep a man at the reservoir cleaning up for a few days after a treatment. These fish eat the dead algæ that falls to the bottom and thus get the most of the copper. No trout, pickerel or bass will be killed with a solution as weak as 1 in 1,000,000 and game fish seem to be immune to this quantity. Mr. Liddell says that the copper will be injurious to vegetation if the water is used for irrigation, but this depends on the strength of the solution and the state of plant growth. Copper sulphate was first used to kill algæ in water-cress beds and thus save the young plants from suffocation by the algæ. Copper solutions will, however, prevent the germination of seeds and the growth of young seedlings in as small a concentration as 1 in 20,000,000.

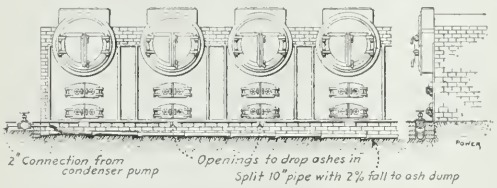
BENJAMIN S. HANSON.

Broad Brook, Conn.

Uplift the Boiler Room

The editorial upon the above subject in the June 24 issue was timely. In many boiler rooms of moderate size the firemen are practically doomed to continue the disagreeable job of wheeling out hot ashes, owing to the cost involved in the installation of an ash-handling system.

Possibly an account of how the difficulty was overcome at one plant may help out some brother engineer, who has



SEWER FOR CONVEYING ASHES

similar conditions to contend with. An ash-handling system was proposed for the plant in question, but when the management heard what the equipment would cost, there was a prompt command for all hands to forget it.

The chief engineer, however, was not easily discouraged, and he began to look around to see if there was not some kind of home-made system that could be installed without the management being any the wiser. Plenty of water was available, and the boiler room was so located that there was a low, swampy place on one side, into which the ashes were dumped. The chief got a few lengths of cast-iron pipe, about 10 in. in diameter, that had been left over from another job. He had these pieces split open lengthwise, and used them to form the bottom of a trough, which was laid in front of the boilers, as shown in sectional view. The sides of this trough were made of brick and iron floor plates were used to cover the top of the trough. These floor plates had rectangular openings in them, opposite the ashpit doors, and light covers were used to close the openings in the floor plates when the system was not in use. The covers were provided with rings so that they could be easily removed with a poker.

The bottom of the trough was laid with a fall of about 2 feet in 100 ft. and the discharge end of the trough was located at the ash dump. At the upper end of the trough, there was placed a 2-in. pipe connection from the condenser pump, and when it was desired to clean fires, the valve on this pipe was opened and a stream of water was allowed to flow through the trough, while the ashes and clinker were being raked into it.

The ability of a 2-in. stream of water to move objects in a trough of the size given, and with the fall stated above, is remarkable. No clinker that could easily get through the openings in the floor plates (which were 6x18 in. in size) seemed to have the least trouble about being carried out, and pieces of brick could be dropped in while ashes were being drawn, and they would be carried along the same as the clinker.

The accompanying figure will show how the trough was arranged, and anyone who has similar conditions in regard to a place to deposit ashes will do well to install this system. The water used during operation is considerable, but it is used only at infrequent intervals and during short periods of time, and the amount used per day is really small. The ashes do not tend to collect at the discharge end of the trough, as might be expected, but will spread over a wide area, particularly if the ground slopes down from the discharge end of the trough.

J. E. TERMAN.

Hartford, Conn.

Making a Flue-Gas Analysis

After reading over the Engineers' Study Course article on "Making a Flue-Gas Analysis" in the July 8 number I would like to suggest a second method of obtaining the zero reading in the burette.

Pump in a sample of gas, close the three-way cock and remove the pump in the usual way. Raise the leveling bottle until the gas in the burette is under a slight pressure and open the three-way cock to the air. Close the three-way cock when the water is within a half inch or so of the zero line. This may be done quickly as long as care is taken that the water does not rise above the zero line.

Now raise the leveling bottle and compress the gas until the water level is exactly on the zero line and pinch the rubber-hose connection either with the pinch cock, or, as will be found easier, with the fingers. Place the leveling bottle on top of the apparatus or any place, as its position will have no effect on the water level as long as the hose connection is pinched. Open the three-way cock to the air for an instant and close it again.

Finally release the pinch cock and check up the zero reading by holding the water level in the leveling bottle opposite the water level in the burette.

I have used this method for a long time and it is seldom that the zero reading will vary more than 0.1 of 1 per cent. Such a variation may be subtracted or added to the per cent. of CO_2 obtained in the subsequent absorption and the error will become negligible. I can strongly recommend the above method, not only for accuracy and reliability but also for ease and speed of performance.

LOREN L. HEBBERD.

Milwaukee, Wis.

INQUIRIES OF GENERAL INTEREST

Conical Pistons—Why are the pistons in some engines made conical in shape?

W. C.

To reduce the weight for a given required strength.

Boiler Joint—In a double-strap butt joint why is the wide strap inside and the narrow strap outside?

W. C.

The narrow strap is placed on the outside of the boiler as the pitch of the rivets along the edge of the narrow strap is small enough for the calking pitch.

Boiler Safety Factors—Why should a larger factor of safety be allowed for stays and staybolts than for the shell of a tubular boiler?

W. C.

Because they cannot be inspected so minutely and the material is more likely to contain hidden flaws.

Metal Melting Points—What are the melting points of babbit and zinc?

A. C. H.

Zinc melts at 786 deg. F. Commercial babbit metal is made in a variety of proportions of copper, antimony, zinc and frequently lead with an average melting point of about 1000 deg. F.

Rate of Spring Flow—What is the best way to measure, approximately at least, the rate of flow of water from a spring?

W. K. G.

The best and most convenient way is to measure the discharge by a weir. A complete description of the construction and use of weirs is given in "Power," Dec. 28, 1909, pages 1090-1094.

Space Over Bridge Wall—How large should be the cross-sectional area of the space between the under side of a horizontal tubular boiler and the bridge wall?

W. C.

Never less than the cross-sectional area of the tubes to insure full draft area, but it may be anything larger if the bridge wall is high enough to prevent the fire from being pushed off the grate.

Safer Boiler—For the same size and capacity and to carry the same pressure, which is the safer a vertical or a horizontal fire-tube boiler?

W. C.

Vertical boilers are more likely to fail in the tube sheets than horizontal tubular boilers and are likely to become clogged and to burn in their water legs. In these two respects the horizontal boiler is safer.

Boiler Horsepower—How is the horsepower of a boiler determined by test?

W. C.

The quantity of water fed per hour and the pressure at which it is generated into dry steam are ascertained. The feed water should be weighed, and the equivalent evaporation in pounds from and at 212 deg. F. per hour divided by 34½ would be the performance in boiler horsepower.

Bearing Boxes—Why do some engines have bronze boxes in the crosshead end and babbitt boxes in the crankpin end of the connecting rod? Is it not better to have babbitt boxes in both ends?

W. C.

Crosshead boxes are not so frequently babbitted as crankpin boxes as the former do not require renewing as frequently as the latter, the wear being less on the crosshead pin.

Expanding Boiler Tubes—When expanding tubes in return-tubular boilers, how much pressure, if any, should there be on the boiler and should the plate be hot or cold for best results?

M. W. C.

The tubes of return tubular boilers should be expanded with boiler empty and cold, otherwise the tubes will contract away from the tube sheets and leak when they become cooled down.

Four Valve vs. D-Slide Valve—In respect to valve setting, what advantage has a four-valve engine over a D-slide valve engine?

G. A. M.

A four-valve engine has the advantage that admission and exhaust are controlled independently for each end of the steam cylinder, whereas, in a D-slide valve engine, the valve being in one piece or assemblage of pieces whose relative position is fixed, setting the valve for regulating either admission or exhaust on either end of the cylinder, affects all other distribution.

Parabolic Governor—What is the difference between a parabolic and an ordinary governor?

W. C.

In the ordinary governor the balls swing on circular arcs; in the parabolic governor they are constrained to follow parabolic arcs. The former governor is not isochronous, i.e., does not give absolutely uniform speed at all loads. The parabolic governor, by virtue of its construction, is satisfied at only one certain speed, and, regardless of load, assumes a position which maintains that speed. The parabolic governor is not built because its refinement of regulation over the ordinary governor is not commercially warranted.

Laying Out Steam Pipe—What precautions should be taken in running a steam main from a battery of boilers? Where and how should the main stop valve be placed?

W. C.

Precautions should be taken to avoid strains on the pipe and fittings from expansion and contraction, to hang and support the pipe so that it may have perfect freedom in expanding and contracting, and to provide proper pitch and facilities for draining the pipe of water of condensation. The main stop valve should be as near as possible to the main boiler header, and, if a globe valve, should be placed with the spindle horizontal with the valve closing against the source of pressure.

Cause of Leaky Tubes—Would closing the damper in the stack cause the tubes in a boiler to leak? The boilers are fired with kiln-dried sawdust and shavings through self-feeding spouts from a blower system.

M. W. C.

Boiler tubes leak from expanding and contracting unequally with the tube sheet and the more frequently the temperature is raised and lowered the sooner will the tubes leak at their joint with the tube sheet. In so far as the use of a damper may be the cause of fluctuations in the temperature of gases which come in contact with the tube ends, the presence of the damper may be charged with causing leakage of the tubes.

Boiler Equalizers—Where three supports are necessary on each side of a horizontal boiler, why should equalizers be used? What is an equalizer?

W. C.

Equalizers prevent an undue portion of the load from coming on any one or two of the supports. Three supporting brackets on a side would not be equally loaded if one bracket support settled down lower, or, from expansion of the supporting walls, was raised higher than the relative heights of the brackets on the boiler. An equalizer is like a whiffle tree supported at its center of length and having suspending rods (like traces) for suspending a boiler bracket from each end in the same manner that equalizers are used on the sides of a locomotive for suspending the side frame by levers, which are supported on the axle boxes.

ENGINEERS' STUDY COURSE

Evaporation

Solution of Chimney Problem

The draft required for the breeching is,

$$(50 \times 0.001) + (2 \times 0.05) = 0.15 \text{ in.}$$

which, added to the draft required by the boilers, makes a total of

$$0.15 + 0.4 = 0.55 \text{ in.}$$

for breeching and boilers. The rated boiler horsepower of the installation is

$$8 \times 500 = 4000$$

and as this will be subject to a 25 per cent. overload we must provide a chimney for

$$4000 \times 1.25 = 5000 \text{ hp.}$$

As it is estimated that 4 lb. of coal will be required to develop one boiler horsepower, the total maximum consumption will be

$$5000 \times 4 = 20{,}000 \text{ lb. per hr.}$$

The total grate area is

$$83 \times 8 = 664 \text{ sq.ft.}$$

Hence, the pounds of coal burned per square foot of grate per hour are

$$20{,}000 \div 664 = 30.12$$

And the draft required for the combustion of bituminous slack at the rate of 30 lb. per square foot of grate per hour is, according to the table given last week, 0.4 in. of water. Then, the total available draft necessary is

$$0.55 + 0.4 = 0.95$$

Applying this figure in the formula for estimating the height of chimney we have

$$H = \frac{1.25 \times 0.95}{0.52 \times 13.57 \left(\frac{1}{520} - \frac{1}{1040}\right)} = 180.47 \text{ ft.}$$

is the required height of chimney above the grates.

Employing the formula for figuring the necessary cross-sectional area of the chimney we have

$$A = \frac{20{,}000}{16.65 \sqrt{180.47}} = 89.44 \text{ sq.ft.}$$

which would mean a chimney 10 ft. 8 in. in diameter.

Water

Water is an indispensable commodity in almost every phase of life and industry. Agriculture would be an impossibility without it. The human being himself would not amount to much if it were not for water, for his substance is more than half made up of that common-place fluid. A modern power plant, no matter of what type, could not be operated if water were not available.

Then, in view of the all-importance of this fluid, it would seem desirable for everyone to know something about its character and habits. As a complete treatment of the subject would be too extensive for the limited space permitted for its discussion here, and as the great majority of the readers of this department are concerned mainly with the operation of steam plants, only those characteristics of water will be taken up that are prominent in the steam plant.

Water is composed of the two gases, hydrogen and oxygen combined chemically in the proportion by volume of two parts of hydrogen and one part of oxygen. The chemical formula is H_2O, which should be familiar to all who have followed this series from the start, as water is the product formed by the combustion of the hydrogen found in such fuels as coal, oil, gas, etc. The reaction which takes place was explained in the first and third lectures on combustion, April 22 and May 6 issues, respectively.

Water in the liquid state and at 62 deg. F. weighs 62.355 lb. per cu.ft. Its weight or volume varies with changes in temperature. At 212 deg. F. the weight per cubic foot is 59.76 lb. and at 32 deg., 62.418 lb. Because of this difference in weight at different temperatures, circulation can be established by applying heat. The water in the bottom of a system expands or becomes lighter when heated and rises or is forced up by the heavier cold water above, which flows down and takes its place and in turn is heated and rises.

Boiling Temperature

If sufficient heat is applied to water in its liquid state it will commence to boil. This boiling results in some of the water being converted into a vapor which is called steam, and if the boiling is continued all the liquid will be changed into steam. The temperature at which water will boil depends upon its purity and the pressure to which it is subjected. Pure water in an open vessel subjected to the normal atmospheric pressure at sea level of 14.7 lb. per sq.in. boils at 212 deg. F. The common impurities found in water in its natural states tend to raise the boiling temperature. Thus, sea water which contains salt as its principal impurity will not boil under atmospheric pressure until the temperature reaches 213 deg. or a little higher, depending on the exact percentage of the impurities contained. The influence of impurities on the boiling temperature is very slight (compared with the influence of pressure), and as the water used in steam boilers never contains but a comparatively small quantity of impurities, this influence is customarily neglected in steam-plant work.

For every pressure there is a fixed temperature at which water boils. The higher the pressure the higher the boiling point. If the temperature of boiling water or of the steam being formed therefrom is known, the pressure can be ascertained without a gage, simply by referring to a table of temperatures and pressures, as these always correspond. In a like manner, if the pressure is known the temperature can be determined without a thermometer.

The same principles apply when water freezes to form ice. Pure water at the normal atmospheric pressure at sea level (14.7 lb. per sq.in.) freezes at 32 deg. F. Impurities tend to lower the freezing point. Thus, ordi-

ıary sea water freezes at about 27 deg. The higher the ›ressure the lower the freezing point.

When water is undergoing the process of boiling the steam formed has the same pressure and temperature as the boiling water from which it is being formed or evaporated. Such steam is known as saturated steam.

Now, if heat is applied to the steam itself and the containing apparatus is arranged in such a manner that the steam is not in close contact with water and hence cannot impart this extra heat to the water to form more steam, the temperature and pressure will both tend to rise. But the new temperature of the steam will not correspond with the boiling temperature of water at a pressure equal to the new pressure of the steam. The temperature will be higher. Such steam is called superheated steam.

To sum up, then, the boiling point of water depends upon the pressure; the boiling temperature is fixed and unchangeable for any given pressure. Saturated steam is steam that has the same temperature as boiling water under equal pressure. Superheated steam is steam that has a higher temperature than boiling water under the same pressure.

Saturated steam may be dry or wet. Dry saturated steam is steam that has been thoroughly evaporated and does not carry any drops, globules, or particles whatsoever of liquid water in the form of a spray or mist. A clearer and more definite explanation of the difference between dry and wet steam will be given further on.

Evaporation

Ebullition is the name sometimes given to the process of boiling or steam generation; a commoner name is evaporation. We speak of the evaporation per pound of coal, equivalent evaporation, etc. Then, there is another term often used: vaporization, the process of changing from a liquid to a vapor, that is, of changing from liquid water to steam. Although the last two terms really mean the same thing, custom has established a slight distinction. Evaporation has come to mean the whole process of making steam, starting with the warming up of the feed water to the boiling temperature and including the actual conversion of the water into steam, while vaporization has come to be considered simply the actual conversion from water at the boiling point into steam at the same temperature and pressure.

Latent Heat

When we apply heat to a body we instinctively think of an accompanying rise in temperature. For instance, if we apply heat to a piece of iron we know that the temperature of the iron quickly goes up. When we apply heat to water, say, at 60 deg., the water grows warmer—its temperature rises. The water will continue to get hotter, the more heat we add, until the boiling point is reached. If the water is in an open vessel and at sea level this point will be at the 212 deg. mark. Now, right here a strange thing will occur. The water will fail to get any hotter. No matter how much heat we apply, no matter how hard we force the fire or how high we turn the gas burner, whichever it happens to be, the thermometer will stick at 212 deg. If you doubt this, try the experiment with a pan of water and thermometer and convince yourself.

The water will cease getting hotter, but at the same time something else will happen. The instant the boiling point is reached ebullition—the process of steam generation—will set in. The question naturally arises: If the temperature cannot be increased by applying more heat, what becomes of this extra heat? It is used in converting the liquid water into steam. As soon as the heat is shut off the boiling or steam-making will cease, proving that heat is required to convert the water from the liquid into the vaporous state. The more heat we apply the more rapid will be the rate of steam generation.

It requires 970.4 B.t.u. to change 1 lb. of water at atmospheric pressure and a temperature of 212 deg. into steam at the same temperature. Just why so much heat is used up or absorbed without causing a rise in temperature when water is broken up into steam I will not attempt to explain here. The only really important thing to know is that such is the case. The heat thus absorbed is called latent heat of vaporization or the latent heat of steam. The term latent means hidden or secret. Hence, the latent heat of steam is the heat that is taken up and hidden by the water when it changes from its liquid to its vaporous state. We consider the heat as being latent or hidden because we can see no evidence of its having gone into the steam as far as the thermometer can tell us.

When steam condenses the heat transfer is the other way. If a pound of steam at atmospheric pressure were injected into a tank containing 99 lb. of water at, say, 60 deg., so that all the steam condensed back into water, the temperature of the resulting 100 lb. of water would be 71.2 deg., showing a rise of 11.2 deg. for the original 99 lb. of water.

The temperature of steam at atmospheric pressure is 212 deg. Hence, the drop in temperature was only

$$212 - 71.2 = 140.8 \ deg.$$

But the 99 lb. of water rose 11.2 deg., showing that

$$99 \times 11.2 = 1108.8 \ B.t.u.$$

were imparted to it. (One B.t.u. being the amount of heat required to raise the temperature of 1 lb. of water 1 deg.)

If the steam had been condensed before it was injected into the 99 lb. of water so that it went in as a liquid at 212 deg. instead of a vapor at 212 deg., the rise in temperature of the 99 lb. would be only 1.52 deg. because the pound of condensed steam or water at 212 had only

$$212 - 60 = 152 \ B.t.u.$$

more in it than a pound of the cooler water.

Some, who are just beginning the study of evaporation and steam, may experience a little difficulty in realizing that steam has weight, and, hence, may be slightly confused when they come in contact with such terms as pounds of steam, etc. This confusion is all the more likely because the pressure is also spoken of in terms of pounds.

In an earlier lesson (April 22 issue) it was shown that a gas has weight, and in the same manner it could easily be demonstrated that steam has weight. In fact, the weight of steam can be ascertained more easily than the weight of a gas; all that is necessary is to condense the steam and weigh the resulting water. In referring to a quantity or weight of steam the word "of" is employed. Thus, we say, 9 lb. *of* steam evaporated per pound of coal. Which means that the combustion of a

pound of coal has caused the evaporation of 9 lb. of water, resulting in the generation of 9 lb. of steam.

In referring to pressure we use the word "at." Thus, steam *at* 150 lb. Which means steam which causes or possesses a pressure of 150 lb. on each square inch of the surface confining it.

⁂

Autogenous Boiler Welding

It has been the editor's privilege to spend some pleasant hours with Theodore Kautny, the leading authority of the world upon autogenous welding. Under his direction numerous classes have been established in the industrial schools for teaching the process. He is the author of several standard works upon this subject, and finds time in the intervals of an extensive consulting practice to direct the publication of *Autogene Metallbearbeitung*, a monthly journal devoted to this specialty. He has consented to furnish some articles to future issues of POWER showing how this process is employed for engine and boiler repairs and in improved methods of manufacture of power-plant apparatus.

In reply to an inquiry as to the possibility of the replacement of the riveted joint by the autogenous weld in steam boilers, Mr. Kautny said that there are promising possibilities in that direction, but that he is exerting his influence to withhold any serious attempt in that direction until a means has been found of proving the soundness of the weld. To this end a prize of 1500 marks has been offered for the best suggestion of a method of testing, which offer has brought out 26 replies. These are to be referred to a committee consisting of Prof. Dr. Schlesinger, of the Technical High School, Charlottenburg; Geheimrat Prof. Dr. Ing. Wüst, of the Metallurgical Institute, Aachen; Prof. Banmann, of the Royal Technical High School, Stuttgart; Ing. Herrn. Richter, of the Technical State Schools of Hamburg; Overingenieure K. Schröder, of the Huldschinskywork at Gleiwitz (Silesia) and Mr. Theodore Kautny himself, for the award of the prize. The suggested methods include heat and electrical conductivity, sound, vibration, etc.

The autogenous weld is already extensively employed to join nozzles onto large work, like receivers, etc., and when the joint is properly made it is as strong as the metal itself. It only remains to be able to check the workmanship.

Mr. Kautny has also an ingenious demonstration of the effect of changes of temperature and stress in producing distortion and strain in riveted joints. This consists in plotting the expansion of the various parts under differences of temperature and making some 500 drawings showing the successive positions. When these are photographed and run through a kinematagraph the movement of the sheets and rivets will be visually reproduced. As an instance of the effort to avoid the riveted joint, Krupp is making some drums for water-tube boilers for the Russian Government about 10 ft. in length and between 2 and 3 ft. in diameter, by boring out large forgings, leaving a cylinder or shell of something over an inch thick.

⁂

Hard Coal Production—Anthracite coal shipments in the first seven months of 1913 were over 40,000,000 tons. This year's production of anthracite coal will probably exceed the high record of 1911, which was 69,954,299 tons, and pass the 70,000,000-ton mark.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Out Seattle way, if the street merchant would continue to roast peanuts, he must qualify as an engineer—a goober engineer, a steam peanuter. We already have a few "peanut" engineers who roast— What we started to say was, Boiler Inspector Albert Johnson declares that the peanut roaster is dangerous, and the operators must be licensed. Men have been killed through careless handling of the deadly little steam boiler. Sure, license everybody who makes steam; raise the standard from peanuts to power house. Then sic the noise-prevention committee onto the peanut engineer's blooming whistle.

⁂

Shank to get 45 bee stings—Headline.

About half a sting will ordinarily more than satisfy the average shank. This particular Shank is Lew Shank, mayor of Indianapolis. Lew has "a tech ob de mis'ry," and hopes by this means to effect a cure.

⁂

We should worry about the coal supply and get a cinder in our eye! A man named Wade, from Philadelphia, has waded to some purpose, he thinks. Wade claims he can combine the water gases with oil, expand and bake them, and thus have a fuel. About a column of newspaper rough stuff tries to explain his process and apparatus—but what's the use, you wouldn't believe it.

⁂

Like all papers with a large correspondence, "Power" occasionally receives some queer spelling, but we raise our Panama to New York's Street Cleaning Commissioner: Here's his list of spellings of "garbage:" "Grabbrage, carbage, garbages, garbege, gabbage, cabbage, garbagge, garbach, gobbage, garbbes, garbadge, garbeg, garbig, garbish, garbige, gurbabe, garbrage, cabage, cabbage, carbbage, garvages, gabbade, carbig, carrbage, garrebge, gabbatche, carribag, garbitsch, garbich, garbetz, gorbige, gerbag, garbager, garbet, gorbage, garrabage, gobers, garbabege, garberg, garbedg, carbiche, gerban, garbetch, garbegge, fabage, grarbage, gabes, garbit, garbush, carbag." They've bin havin' a swill toime, says Cassidy. A list of th' odors would fill a book.

⁂

It's been said that the English dearly love a title. However true this may be, and at the risk of precipitating a war between the two countries, we have been told that in Germany lives a professor who gets mad enough to sue the paper which neglects to give his full title when mentioning his name. To escape a libel suit, his last name is omitted (it has only four letters, anyhow, and will never be missed). Here's the title: Herr Geheimer Regierungsrath, Professor Doctor-Ingenieur Doktor Friedrich ———. Over here, you'd have to get good and mad before you could make even a fair stab at it.

⁂

Twenty pounds weight may now be sent through the mails. Keep this in mind when planning your trip to the N. A. S. E. convention at Springfield. This is a friendly tip to the souvenir gatherer. He may send his spoils home by the parcels post. Of course, if he has collected over 20 lb., and it's going to crowd his luggage, it would be safer to hire a box car.

⁂

Glory be, Jawn, here's another wan av thim newspaper cylinder-head bust-ups. This toime it do be in th' Noo Yawk Criminynal Coorts buildin'. Th' cub who wrote it up declares that an outrajus flood, which engulfed Rosie M'Carty, the butiful tillyphone operatress, wuz caused by "th' blowin' out av a wather-pipe cylinder head." An' sez he, brave Rosie stuck to her post; she niver moinded th' slathers of plaster an' fallin' debree which threatened to engulf her. An' whin the crool flood had subsided, th' little darlint sthill sthuck, 'till relaysed be th' rescuin' populace. True for you, Jawn, they niver found th' devastatin' wather-poipe cylinder head that caused all th' ructions. 'Twould sarve that rayporter chap roight if they made him luk fer it—an' kep' him on th' job till he found it!

Michigan N. A. S. E. Convention

The twelfth annual convention of the Michigan State Association of the National Association of Stationary Engineers was convened in Grand Rapids, on Aug. 6, with Press Hall as the meeting place and exhibit building. Bert Wells, of the local committee, presided at the preliminary ceremonies on Wednesday morning in place of Chairman Chas. W. Merritt, who was unavoidably prevented from being present by serious illness in his family. The Rev. J. R. T. Husted pronounced the invocation and in the absence of Mayor Geo. E. Ellis, also delivered the address of welcome, to which National Secretary Fred W. Raven responded. Lee H. Bierce, representing the Grand Rapids Association of Commerce, gave an interesting address, setting forth the opportunities existing in the city. John W. Lane, editor of the "National Engineer," responded.

State President W. M. Gormley was then introduced and the various committees were appointed. In the absence of National President John F. McGrath, State President Gormley officially opened the exhibit hall and A. T. Arens, of Jenkins Bros., gave a brief address on behalf of the exhibitors.

At the Thursday morning session the matter of a state license law was taken up and the educational prizes were awarded. In its report the license-law committee described some of the obstacles and difficulties encountered by it in attempting to have a bill put through by the state legislature. Continued effort toward the passage of the bill is to be made this year. The first educational prize, $20 in gold, donated by J. D. Swartwout, of Saginaw, was won by Arthur M. Adams, of Kalamazoo. The second prize, $10 in gold, presented by the Standard Oil Co., was awarded to G. C. Wetherly, of Saginaw. M. A. Knight, Kalamazoo, won the third prize, a copy of Kent's Mechanical Engineers' Pocket-book, given by Aaron Miller, and W. W. Clark, Saginaw, took the fourth, a slide rule, presented by the S. P. Conklin Co. These prizes were awarded for the best answers to a set of questions issued by the educational committee.

W. A. Sperry, operating chemist of Grand Rapids' new filtration plant, gave a lecture on the principles and features of the plant. His talk was followed by an address by G. G. Whitworth, treasurer of the Berkey & Gay Furniture Co., on "The Engineer from the Manufacturer's Viewpoint." In the course of his remarks the speaker declared that there was a tendency on the part of people generally to consider a genius as a fellow who is divinely gifted. The true cause of genius, however, is inclination for hard work, intense study along the line on which one aims to progress. Luck is governed largely by personal application.

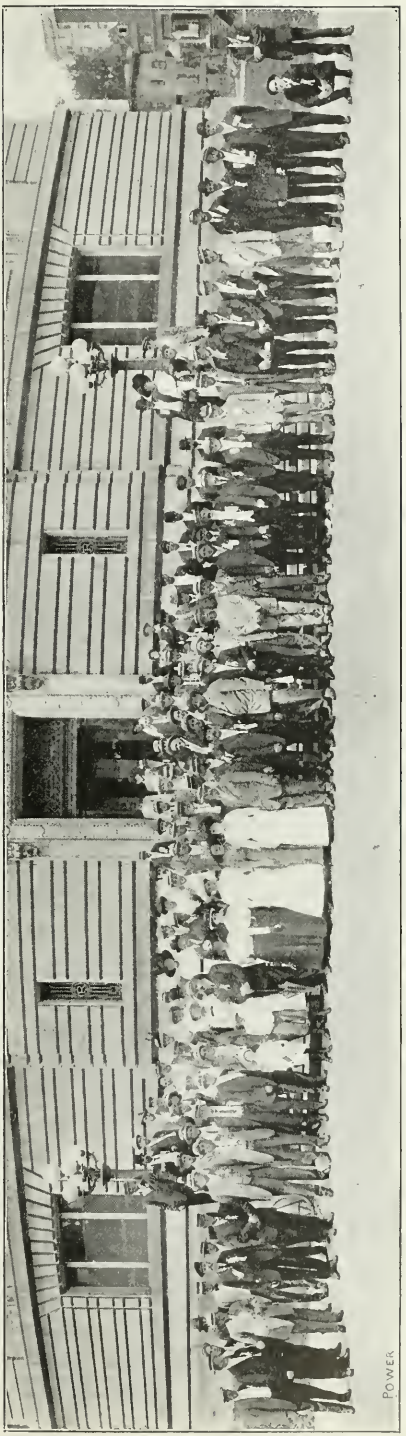
In responding, F. A. Wells, chief engineer of the Michigan Leather Co., outlined the purpose of the N. A. S. E. and declared that one of the important objects of the organization was to bring the manufacturer and engineer into closer touch.

At the annual election, which was held on Friday morning, these officers were chosen: A. W. Miller, Detroit, president; John Andrews, Pontiac, vice-president; E. C. Smith, Kalamazoo, reëlected secretary; H. T. Bagley, Owosso, treasurer; G. T. Maloney, Owosso, conductor; Otto Mauthe, Muskegon, doorkeeper; Fred Tisch, Flint, trustee; H. A. Pierce, Kalamazoo, state deputy. Muskegon was chosen as the place for the next annual state convention. Past National President C. W. Naylor, National Secretary Fred Raven, and John Lane, editor of the "National Engineer," made brief appropriate addresses after the election.

Chief among the entertainment features of the convention program was a baseball game and picnic on Thursday afternoon and evening at Ramona Park, an amusement resort near the city. The game was won handily by the engineers, who made a score of 10 runs against the 4 by the supply men. On Wednesday afternoon an auto ride was provided for the lady guests and on Thursday morning they made a shopping trip to the principal downtown stores. On Wednesday evening an informal entertainment consisting largely of musical numbers by talented representatives of the supply houses was given in the exhibit hall and on Friday evening the Grand Rapids Evening Press Newsboy Band gave a concert in the same place. On Friday afternoon a visit was made to the new filtration plant and the city water works.

Over 40 booths in the exhibit hall were occupied by the displays of the following concerns:

Falls Machine Co.
Anchor Packing Co.
Crandall Packing Co.
Hawkeye Compound Co.
United States Graphite Co.
Standard Oil Co.
Grand Rapids Supply Co.
Garlock Packing Co.
Grand-Rapids-Muskegon Power Co.
Arrow Boiler Compound Co.
Crane Co.
Aaron Miller.
Diamond Power Specialty Co.
Ranlville Co.
White Star Refining Co.



GROUP AT MICHIGAN STATE N. A. S. E. CONVENTION, GRAND RAPIDS, AUG. 6, 7 AND 8

Lagonda Manufacturing Co.
Harrison Safety Boiler Works.
Viscosity Oil Co.
Jenkins Bros.
Greene, Tweed & Co.
Dearborn Chemical Co.
V. D. Anderson Co.
Lunkenheimer Co.
Underfeed Stoker Co. of America.
"Power."
Barclay, Ayers & Bertsch Co.
Kenneth Anderson Co.
J. L. Wernette.
Wickes Boiler Co.
Lake Erie Compound Co.
Richards Wilson Pipe Covering Co.
International Correspondence Schools.
Buckeye Chemical Co.
Bousman Mfg. Co.
Wm. Powell Co.
Leitelt Iron Works.
Central Boiler & Supply Co.
Nelson Valve Co.
Hills-McCanna Co.
Cahall Boiler Co.
Breen & Halladay Fuel Co.
Albany Lubricating Co.
Fairbanks Co.
H. W. Johns-Manville Co.
C. A. Dunham Co.

❖

CORRECTION—On page 255 of the Aug. 19 issue, Figs. 2 and 3 are in error in that the bridge-wall is shown extending up to the bottom of the tubes. With the horizontal baffles it should, of course, be considerably lower to allow a passage for the gases.

❖

Graft in Chicago Smoke Department

Nine of the deputy smoke inspectors for the City of Chicago have been on trial before the Civil Service Commission, charged with petty graft, favoritism, false reporting, insubordination and loafing. Eight of the nine were promptly convicted and ordered discharged from the service.

Chief Smoke Inspector Osborn Monnett has had private detectives at work on the movements of his subordinates for several months past and according to the testimony given in the trial a fine record of contemptibly small grafting has been unearthed. It was brought out that some of the large manufacturing concerns in the city whose chimneys were smoking offensively were in the habit of giving presents and even sums of money to the deputy inspectors to win freedom from unfavorable reports. Such commodities as ham, bacon, shoes, neckties, etc., were on the list of "gifts" said to be received regularly by the accused men. The agents of certain coal companies are alleged to have claimed that they have a "pull" with the smoke-inspection department and that if coal was purchased from them no trouble would be caused by the department if the customer's chimney smoked.

An engineer in charge of a plant in an office building, owned by a large railroad entering the city, testified that the accused smoke inspectors were in the habit of foregathering in his plant and whiling away the weary hours of duty by playing cards and eating repasts generously provided by the packing and manufacturing companies of guilty conscience and temptingly cooked and served by the aforesaid engineer. The selection of this plant as the rendezvous for members of the deputy inspectors' "We-Should-Worry Club." was prompted by an official of the operating department. The inference is that through this little courtesy he won immunity for his company from prosecution for violation of the smoke ordinance by its locomotives.

❖

The International Congress of Refrigeration

Delegates are coming from forty-two countries to attend the Third International Congress of Refrigeration, of which President Wilson is patron, to be held in Chicago from Sept. 17 to Oct. 1. Secretary of Agriculture Houston is honorary president.

More than 5000 manufacturers, scientists, engineers, ice producers and dealers in all sorts of produce which depends on refrigeration to prevent the enormous waste which would otherwise result, will assemble for the congress. The foreign delegates will be mustered at New York where a committee will welcome them. A special train will transport the party to Washington, where they will be received in person by President Wilson and addressed by Mr. Houston. The trip to Chicago will be by special train.

The committee in charge of the congress announces daily executive sessions to be addressed by prominent personages, including Dr. Harvey W. Wiley, former chief of the United States Bureau of Chemistry; Dr. Alex. C. Humphreys, president of the Stevens Institute of Technology; Dr. S. W. Stratton and C. W. Waidner, of the Bureau of Standards, Washington, D. C.; W. C. Brown, president of the New York Central lines; C. W. Secrist, vice-president and general manager of the Pacific Fruit Express; J. M. Culp, vice-president of the Southern Railway; James R. Mann, congressman from Illinois; Professor E. Spencer Baldwin, Boston; Dr. H. E. Barnard, state food and drug commissioner of Indiana, and many others who are prominent in commercial, manufacturing and transportation lines.

Concurrent with the congress will be held an international refrigeration exposition. This is to be the first exposition of this nature ever held. The United States government will have a special exhibit. During the congress a banquet will be tendered to the foreign delegates, at which only cold-storage food-stuffs and beverages will be served.

NEW PUBLICATIONS

ENGINEERING TABLES AND DATA. By W. W. F. Pullen. The Scientific Publishing Co., Manchester, England. Limp cloth; 68 pages; 5½x8½ in.; 3 charts; 7 figures. Price, 1/6.

This work is a collection of tables and data for handy reference in the laboratory, the testing shop and in engineering educational work generally, consisting of tables of circular measure of angles, trigonometrical functions, common and hyperbolic logarithms, exponential and hyperbolic functions, conversion factors (Metric to English and English to Metric measures), water density, specific heat, etc., of various substances, tables relating to fuel and combustion; steam tables in Fahrenheit and Centigrade units; mean specific heat of superheated steam, 20 to 220 lb. absolute; charts of steam dryness for use with throttling calorimeter, of sulphur dioxide and of CO_2; mensuration of the principal geometrical figures employed in engineering computations and standard differential coefficients and differential equations.

The compiler states that steam tables have been prepared upon values obtained by recent experimenters; it is to be regretted, however, that they have been computed on the basis of the old British thermal unit in place of the unit more generally accepted by American engineers, viz.: $^1/_{180}$ of the heat required for raising a pound of water from 32 to 212 deg. F. The resulting differences are small enough to neglect for all practical purposes, but they are annoying and in some cases may be confusing to those accustomed to the more generally accepted American standard.

SOCIETY NOTES

On Sunday, Aug. 17, Local Union No. 68 of the International Union of Steam Engineers of Newark, N. J., held its annual outing at Donnelly's Grove, College Point, N. Y. A big percentage of the members and many friends of the organization enjoyed the day together.

Phoenix Association No. 24, N. A. S. E. of New York City held its 23d annual outing at Donnelly's Grove, College Point, N. Y., on Sunday, Aug. 17. There was the usual big attendance. A baseball game between the members of Phoenix and the "Bunch" was won by the latter, followed by a program of races. A hearty dinner wound up the day's fun.

More than twenty thousand people attended the outing and picnic of the Eccentric Firemen, Local union No. 56 of the International Brotherhood of Stationary Firemen of New York City at Celtic Park, Long Island City, on Sunday, Aug. 17. There was an elaborate program of popular out-door sports with handsome prizes to the winners. Dancing and other enjoyable pastimes were arranged for the ladies. International-President Timothy Healy was on hand to welcome the guests.

PERSONALS

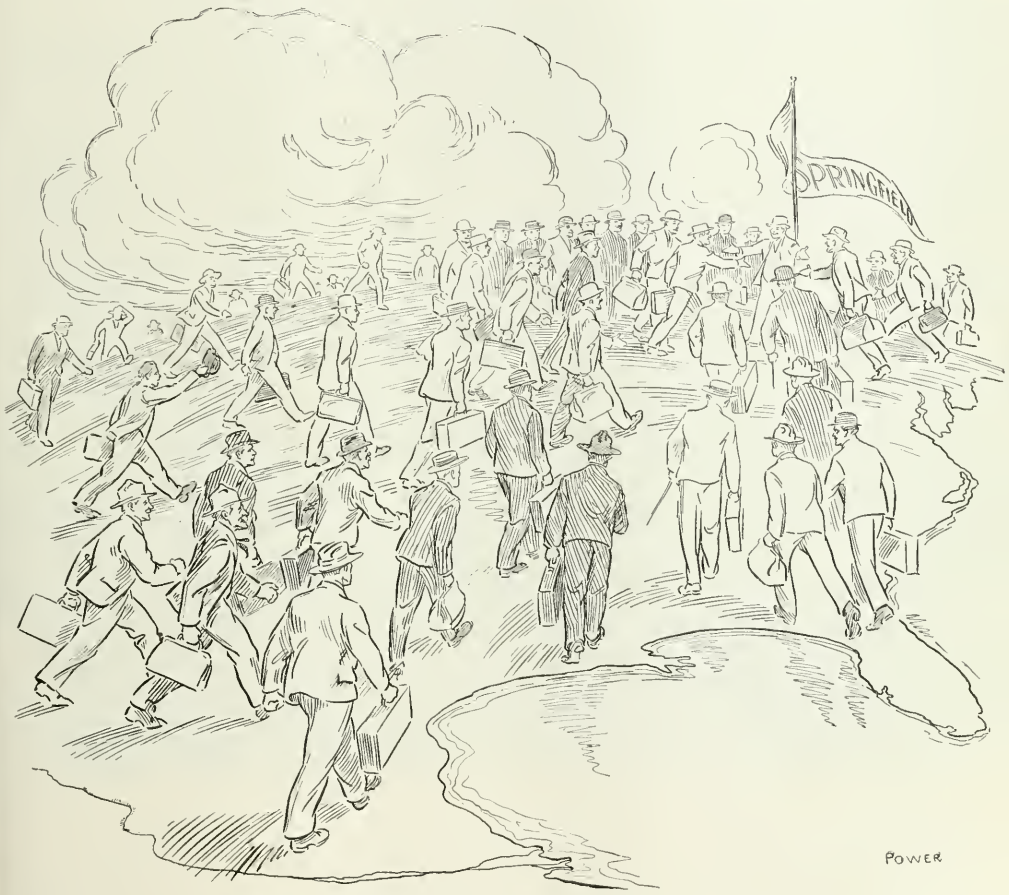
H. C. Behr has resigned as consulting mechanical engineer in South Africa for the Consolidated Gold Fields of South Africa, Ltd., and will engage in professional work, specializing as consultant in the design, construction, operation and maintenance of the mechanical part of mining and metallurgical plants, with office at 233 Broadway, New York.

James D. Robertson, formerly sales manager for the Pittsburgh Valve, Foundry & Construction Co., has again assumed charge of the sales of this company, returning as second vice-president after two years' absence. Mr. Robertson in the meantime has successfully completed the organization, plant and launching in business of the Warren Tool & Forge Co., of Warren, Ohio. He began his business career with Atwood & McCaffrey, and when that concern was absorbed by the Pittsburgh Valve, Foundry & Construction Co., he continued his services and up to the time of his withdrawal had completed his 21st year with the company.

POWER

Vol. 38 NEW YORK, SEPTEMBER 2, 1913 No. 10

ON TO SPRINGFIELD!



One objective: The N. A. S. E. Convention at Springfield.
One object: The Good of the Engineer.

Springfield Electric-Light Plant

By Warren O. Rogers

NOPSIS—This central station contains turbine units both the old and new sections, vertical porcupine boil- supplying them with steam. Motor-driven, direct- rent arc machines are used for street lighting. The dential lighting rate is nine cents per kilowatt-hour; day load exceeds the night load.

::

Visiting engineers to Springfield, Mass., should not to visit the power plant of the United Electric Light at the foot of State St. It is a strictly business position, void of frills and show units, and, although plant, as it stands today, is the result of additions

First, at the head of the company are local men, who have a pride in the welfare of the city, as well as a business interest in the plant in which they have invested their money. The slogan of the company is, "Give everybody the best there is." Result: there is an absence of scathing, condemning articles by the newspapers decrying the actions of the company, the customers are satisfied, the service is good and the rates low for central-station service. For instance, the residential lighting service is charged nine cents per kilowatt-hour and manufacturing establishments using power circuits are charged much less.

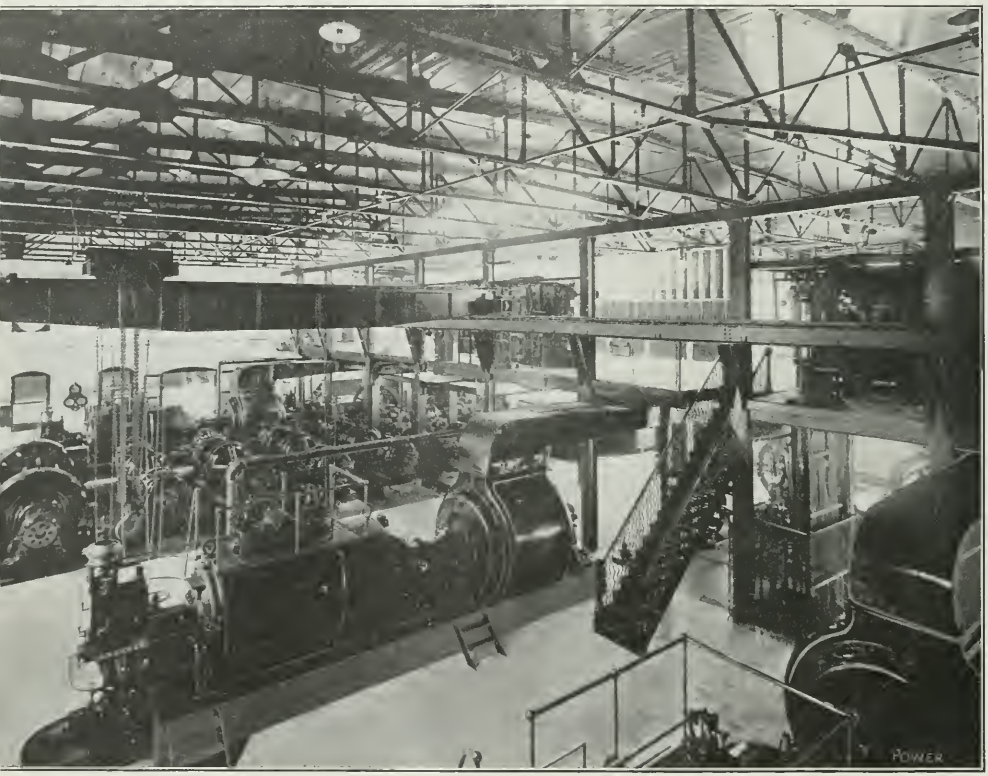


Fig. 1. Old Turbine Room, Arc Machines and Switchboard Gallery

the generating units, from time to time, it is attrac- and well designed.

Years ago the original plant consisted of reciprocating rs and belt-driven line shafting from which the gen- ors were driven. This arrangement was modern at time, but would make a strange contrast with the st design of units found in service there today.

There are many interesting events connected with the ory of the plant in connection with the changes which e taken place and also as to the attitude the officials e taken regarding their relations with the public.

No labor troubles arise to interfere with the harmonious operation of the plant, mainly because the men are treated as men and because those in authority have worked themselves up from humble positions to those of responsibility, and knowing what work is to be done, how it feels to work in the everyday grind of power-plant operation, and believing a man is worthy of his hire, are some of the reasons why the fifty-odd men employed about the plant are satisfied with their positions and with their superiors.

Viewing the plant from the exterior, from the State

st. approach, one sees a rather low red brick building, hrough the double doors of which a glimpse of some f the machines, of what is now termed the old plant, s seen. At the right is a small brick building in which s the office of Chief Engineer Walter H. Damon, and t the rear of which is a well equipped machine shop. At the left is the new boiler room, separated from the ew turbine room by a brick wall. At the rear of the ffice and adjoining the old turbine room is the old boiler oom; the boilers of which are used during the winter eason only, but can be fired up at any time, if necessary.

lead. These two steam mains supply steam to the turbine in the old plant.

Old Turbine Room

Upon entering the old turbine room, Fig. 1, one sees three 1000-kw. steam-turbine units. Two are on the side of the room nearest the boilers, the third is next to the wall dividing the two turbine rooms. No. 2 turbine was the first turbine used in the city and was installed in 1904, and has never cost a cent for repairs. It was among the first built by the manufacturers, being

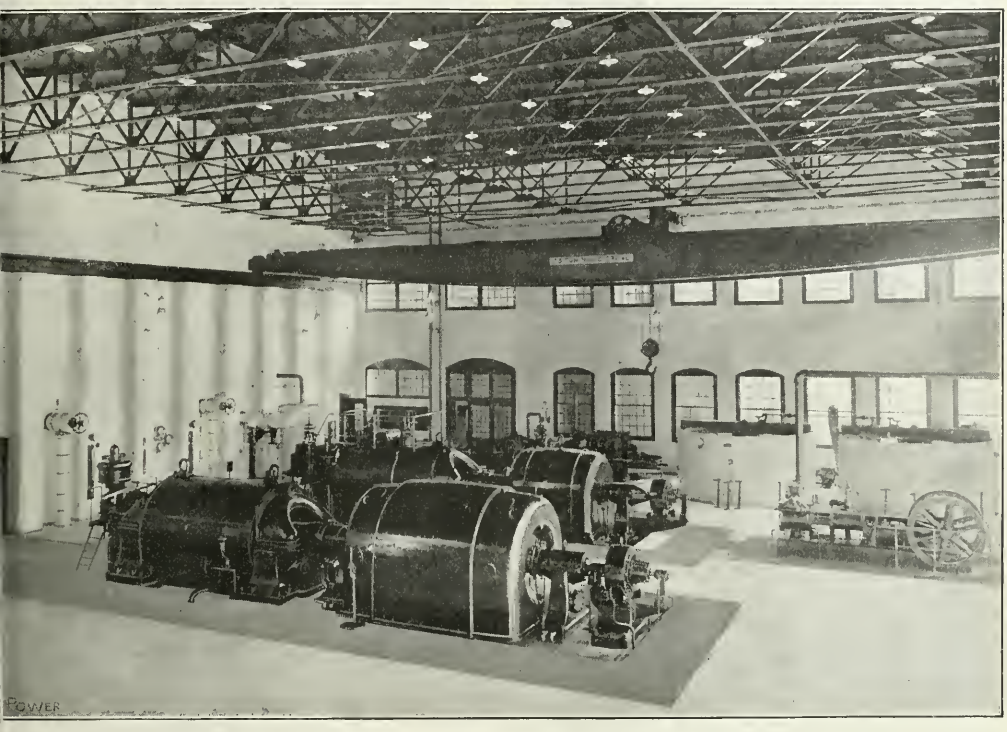


Fig. 2. Two of the Three Turbine Units in the New Turbine Room

As an inspection of the plant is in order, suppose we gin with the old part and go through it with the idea noting the size and equipment of the plant that furshes electricity, without competition, to the population a city of approximately seventy-six thousand.

Old Boiler Room

In the old boiler room there are eight 400-hp. porcuine boilers. Dutch-oven furnaces and mechanical stokrs are used on all of the boilers in both the new and d boiler rooms. The old boilers are set in two rows ad in two batteries, each of four boilers, with a firing sle between.

Coal is delivered to the stoker hoppers by a belt conyor, a double discharging chute distributing the fuel the hoppers of both rows of boilers. Each boiler in ch row is connected to a 12-in. steam main by a 5-in.

No. 98. Nos. 1 and 3 units were operated a year later. The generating end of each turbine is a 1000-kw., two-phase, 60-cycle, 2200-volt generator; the speed of each is 1800 r.p.m.

The vertical jet condensers are in the basement, with the steam cylinders protruding above the turbine-room flooring. The exhaust pipe of No. 1 unit is fitted with a hydraulic-operated valve, the other two exhaust pipes with motor-operated valves. The condenser of No. 1 is at the generator end, as a necessity, on account of the floor area required in the basement, which was restricted at this machine by the wall on one side and the adjoining turbine foundation on the other. The condensers for the other two turbines are at the sides of the steam end. The three dry-vacuum pumps are on the turbine-room floor.

The turbine generators were originally of the open-

casing type, but have since been fitted with air ducts leading from the top of the casing out through the river side of the building, as shown in Fig. 1.

Exciter Units

There are three engine-driven exciter units. One near No. 1 turbine, the other two at the generator end of No. 3 turbine, next to the wall between the new and old tur-

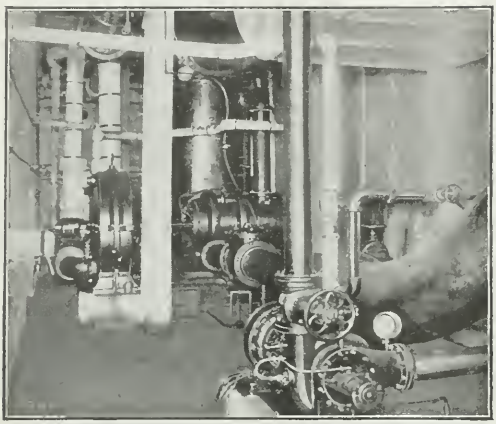


Fig. 3. One of the Condenser Outfits

bine rooms. The direct-current generators are each of 25-kw. capacity. The new turbine generators are excited by self-contained, direct-current generators mounted on an extension of the turbine shaft, as illustrated in Fig. 2. Each delivers 125-volt current. One is of 35- and the other of 50-kw. capacity, and they are attached to 2500- and 4000-kw. turbines, respectively.

Arc-Lighting Units

In the old turbine room there is a 67-hp. induction motor directly connected to a 40-kw. direct-current, 125-

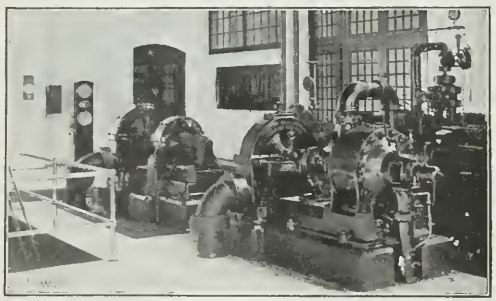


Fig. 4. Turbine-Driven Generator and Centrifugal Pump

volt generator, used to supply energy to a few 110-volt motors throughout the city.

Between Nos. 2 and 3 turbines are the motor-driven arc-light units. There are four 154-hp. induction motors, each connected to two one-circuit direct-current 10,000-volt arc machines, at a speed of 500 r.p.m. There are also six 125-hp. induction motors coupled to 12 direct-current, 8000-volt arc machines at 700 r.p.m. The flexible couplings are made with two flanges holding lengths of round rubber which fit into round spaces. They are prevented from working out endwise by flat plates, and from the top by the overlap of the rim face.

Two 500-kw. rotary converters supply manufacturers with current for motor circuits at 600 volts, at a speed of 600 r.p.m. These units are at the State St. side of the station between the arc machines and the marble arc-lighting plug switchboard. Rubber mattings are placed about these and the arc machines as a precaution against the operator slipping, while working about them, and to eliminate as far as possible danger from electric shock.

New Turbine Room

There are three turbines in the new turbine room, Fig. 2, two of which are shown. One is a single-flow unit; the one in the foreground of Fig. 2 and the new unit are of the double-flow type. They have a capacity of 2500, 4000 and 6000 kw. at a speed of 1200, 1800 and 3600, respectively.

Two of the three turbine units are running and the third is practically ready to operate. Fig. 2 gives a view

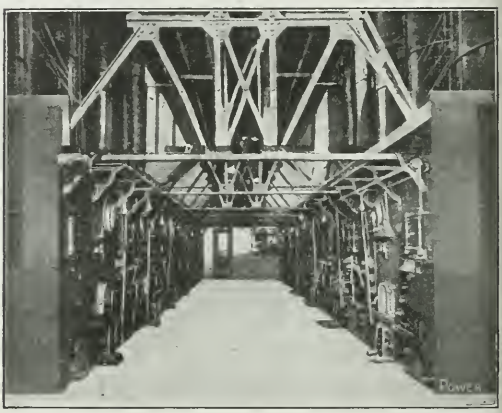


Fig. 5. New Boiler Room, Showing Original Boilers

of the room, including a dry-air pump, the two boiler-feed pumps and the water-filtering tanks. The small turbine exhausts to a 10-in. jet condenser having a motor-driven circulating pump. The dry-air pump on the turbine-room floor is connected with this condenser. The two large turbines are operated in connection with two 18-in. Leblanc condensers, both located in the basement beneath the steam end of the turbine. One of the condensers is shown in Fig. 3.

There is at the far end of the new turbine room, an auxiliary turbine-driven, direct-current, 50-kw., 125-volt generating set that can be used for exciting purposes or for station lighting, if either becomes necessary. The turbine-driven 5-in. three-stage centrifugal pump, shown, is used for boiler feeding, and a second unit, which has been installed in place of the duplex pump shown, furnishes a second unit, consisting of a turbine-driven 6-in. three-stage centrifugal pump. These units are shown in Fig. 4.

Water for condensing purposes and for boiler feeding is taken from the Connecticut River, the circulating water discharging to the river after passing through the condensers. The suction lines of the condenser pumps are fitted with twin strainers between the pump and river. They are necessary on account of leaves, grass and other floating débris being drawn into the suction line and

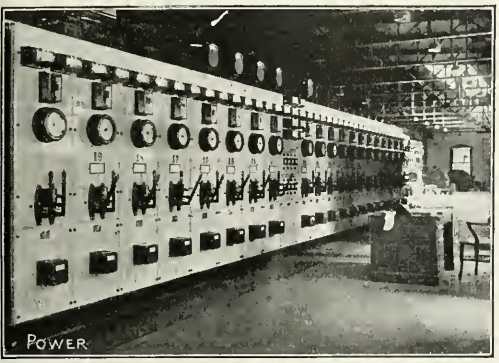


Fig. 6. Main Distributing Switchboard

which would otherwise restrict the flow of condensing water through the condenser. On the new turbine condenser suction line multiple strainers are used.

All boiler-feed water is pumped from the river into two filtering tanks which have a capacity of 460 gal. of water per min. The water is filtered in one tank and is taken from the storage tank by the feed pumps.

New Boiler Room

The new boiler room, Fig. 5, has twelve 400-hp. porcupine boilers and four more of the same type and horsepower are being installed. They have mechanical stokers and carry a steam pressure of 150 lb. The boilers are placed in two rows with a firing alley between, above which a belt conveyor runs, delivering coal from the yard or coal cars as the supply dictates.

Fuel is unloaded from railroad cars, either into a hopper above the crushing rails, or is dumped into a coal pocket in the rear of the boiler room by a grab-bucket hoist, which runs on a track above the same. The conveyor delivers coal to the stoker hopper by gravity through a discharge chute.

Ashes from the stoker drop into an ashpit and are conveyed to an ash bin on the outside of the building, from where they are carted away free of charge by the city for filling-in purposes.

The installation of the four new boilers gave the observer a better idea of their construction than could be obtained by other means. An examination of the standpipe showed that the vertical seam is lap welded, as are also the tubes, and that braces and staybolts are conspicuous by their absence. The standpipe of each boiler rests on a simple foundation, unsecured by any fastenings, and the entire boiler can expand or contract at will without strain to itself or to the brick setting. As practically one-third of the volume of the boiler is devoted to steam space, and as the entire surface is exposed to the heated gases, this space above the water line acts as a superheater.

All tubes are staggered and act as baffles to the gases and eliminate the necessity of putting in brick baffle walls. The weight of water in the standpipe tends to force the tubes full of water, and when the boiler is working there is a descending column of water and an ascending column of steam mixed with water in the standpipe. At the same time there is an ingoing and an outgoing stream in the tubes.

A 16-in. steam header is between the new turbine room and the nearest row of boilers, on the boiler side of the wall separating them. Each boiler is connected to the header by a 6-in. lead, having long-radius bends. All high-pressure steam piping has Van Stone joints. The turbines are fed from the main header through pipe lines coming in through the wall and fitted with an angle-stop valve on the turbine-room side of the wall. The pipes then drop through the floor and connect with the turbines from the basement. All pipes are covered with a suitable covering.

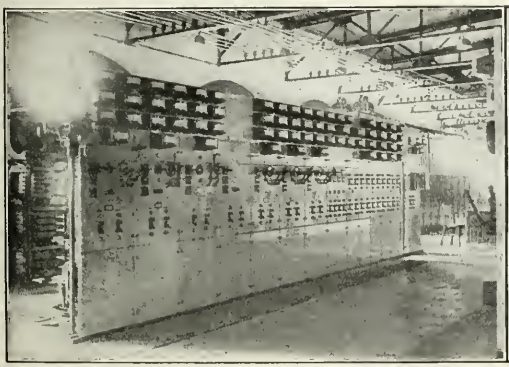


Fig. 7. Generator Switchboard

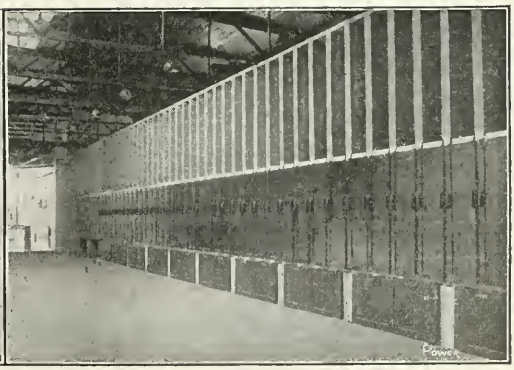


Fig. 8. Busbar Compartments

Switchboards

All switchboards, with the exception of the arc plugboard, are in the old turbine room on a balcony on the

river side of the plant. The balcony is reached by a stairway placed about opposite the entrance doors. The switchboards include one of six panels, used for controlling the rotary converters. It is shown at the far end of Fig. 6. On the main distributing board, of 24 panels, shown in the foreground, are mounted the necessary switches, wattmeter and watt-hour meter. The generator board, Fig. 7, contains 14 panels, six for the generators, the remainder being devoted to the exciter, central, power and lighting circuits.

All high-tension busbars and solenoid-controlled oil switches are placed in concrete compartments, Fig. 8. Eventually all overhead wiring on the balcony will be removed, which will add to the appearance of the gallery and to that of the exceptionally well designed switchboards. A synchronizing dial is placed on both sides of the wall separating the turbine rooms, in sight of the operators and switchboard attendants.

Notwithstanding the many changes which have been made, during the past 20 years, the layout of the various units has been made with an eye to saving floor space without permitting a jumbled appearance, as indicated by Figs. 1 and 2.

Because of the numerous windows in the turbine rooms they are both light and comfortably cool, even on a hot summer's day, and as the plant is built on the bank of the river, the windows on that side of the building can be open without the annoyance of dust blowing in upon the machinery.

For June of this year the average lighting load was 1,000,348 kw.-hr. for the steam plant, which is run in connection with two hydro-electric installations, which have a total capacity of 3000 kw. The day load of the steam plant, which is larger than the night load, is approximately 5000 kw.

PRINCIPAL EQUIPMENT OF THE UNITED ELECTRIC CO.'S POWER PLANT, SPRINGFIELD, MASS

No.	Equipment	Type	Purpose	Kv.-a.	Kw.	Phase	Cycles	Volts	Amp.	Hp.	R.p.m.	Steam Pressure Lb	Size	Manufacturers
24	Boilers	Porcupine	Steam							400		150		Porcupine Boiler Co
24	Stokers	Murphy												Murphy Iron Works
3	Turbines				1000						1800			
1		Single flow	Main units		2500						1200			Westinghouse Machine Co.
1				4000							1800			
1	Turbine	Double flow		6000							3600	150		
1											2800			
1		Single stage	Circ. pumps								2400			Terry Steam Turbine Co.
1			Auxiliary unit							85	2800			
3	Generators				1000			7200	5500		1800			
1					2500						1200			
1		Alt. current	Main units	5000		2	60	5500			1800			
1				6000							3600			
1	Generator				35				280		1200			Westinghouse Electric & Mfg. Co.
1		Direct curre't	Exciter		50				400		1800			
1			Power circuit		40			125	320		850			
3	Generators		Exciters		25				200		350			
4	Generators	Constant cur-rent	Arc circuits					10,000	5		500			
6								8,000			700			
3	Engines	Single acting	Exciters								350	150	8½x8″	Westinghouse Machine Co.
4	Motors	Induction	Arc gen					2300	40 5	154	500			
6					50	2	60	2800	25	125	700			General Electric Co.
1			Circ. pumps					2400	21	35	450			
1	Motor		Generator					2200		61	850			Westinghouse Electric & Mfg. Co.
1	Generator	Direct curre't	Auxiliary		50			125	400		2800			Crocker-Wheeler Co.
3	Condensers	Jet												Deane Steam Pump Co.
2		Leblanc	Turbines										18″	Westinghouse Machine Co.
1	Condenser	Jet											16″	
3	Pumps	Dry air	Condensers										10x22x18	Deane Steam Pump Co.
2	Converters	Rotary	Power		500	2	60	600	834		600			Westinghouse Electric & Mfg. Co.
1		Dry air	Condenser									150	12x22x18	Alberger Pump & Condenser Co.
1	Pump	Three stage	Centrifugal								2800		4″	Jeansville Iron Works Co.
1											2400		5″	Alberger Pump & Condenser Co.
4	Strainers	Twin	Suction pipes											Elliott Co.
2		Multiple												Lagonda Mfg. Co.
2	Filters	Open tank	Feed water											New York Continental Jewell Filtration Co.
1	Crane	Motor opera'd	Turbine room										25 ton	Niles-Bement-Pond Co.

⁂

A railroad cut through coal on the new construction work of the Louisville & Nashville R.R. in the northern part of Alabama has been converted into a profitable mine by the contractor, who is selling the coal to his neighbor contractors.

Efficiency of a Steam Ejector

By F. M. Thomas

Many ejectors for raising water in small quantities are used and while they are known to be "steam eaters," it is not generally appreciated how inefficient they really are. A rough test on a 1½-in. brass ejector of good make and in good repair, gave these results.

Water per minute, 33 gal. or 274 lb. = W

Temperature of water in well was 112 deg. = t

Temperature of water delivered was 142 deg. = T

Water was raised 23 ft.

Total lift including friction taken as 25 ft.

Steam pressure assumed at 80 lb. at the ejector.

The water delivered, W, includes the weight of condensed steam. The water removed from the well is found by an easily derived formula,

$$w = \frac{H - T}{H - t} W$$

where H is the total heat of the steam at 80-lb. pressure, or 1180. We then have

$$w = \frac{1180 - 142}{1180 - 112} 274 = 266.3\ lb.$$

The weight of steam required is of course the difference of W and w or

$$274 - 266.3 = 7.7\ \text{lb.}$$

Water horsepower is

$$\frac{266.3 \times 25}{33{,}000} = 0.202$$

This is useful work.

Weight of steam per hour is

$$60 \times 7.7 = 462\ \text{lb.}$$

Steam per horsepower per hour is

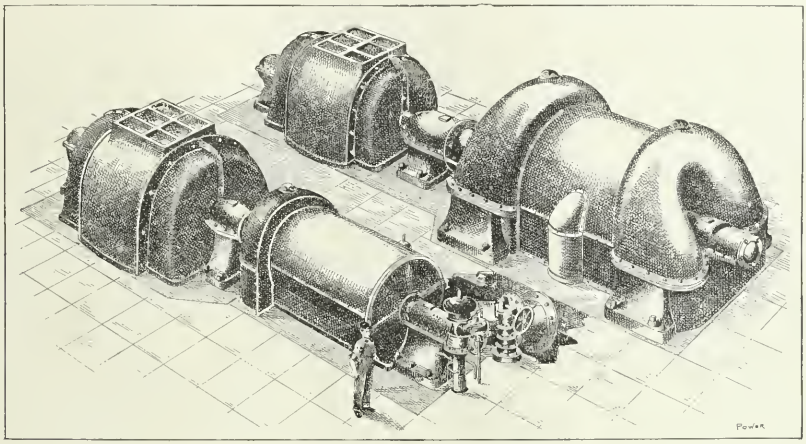
$$\frac{462}{0.202} = 2287$$

This indicates that the use of ejectors is not warranted except where small quantities of liquid are occasionally to be lifted.

New York's Largest Turbine

SYNOPSIS—A 30,000-kw. reaction turbine divided into two elements, the high-pressure running at 1500 r.p.m. and the low-pressure element at 750 r.p.m. There will be two generators, each running at a different synchronous speed.

Not to be outdone by Chicago in turbines of large capacity, the Interborough Rapid Transit Co., of New York City, has recently awarded a contract to the Westinghouse Machine Co. for a horizontal turbine of 30,000-kw. capacity. The feature of this particular unit will be its division into two turbine elements: the high-pressure element being a single-flow turbine, operating at 1500 r.p.m., and the low-pressure element being a double-flow turbine, operating at 750 r.p.m. The machine is of reaction type throughout, and comparatively low blade speeds are involved. It will be installed at the company's Seventy-fourth St. station.



30,000-Kw. "Cross-Compound" Turbine for the Interborough's Seventy-Fourth St. Station

The scheme of employing two turbine elements having the steam pass serially through them is not new. A number of such units of from 1000- to 2000-kw. capacity were built by the Westinghouse Co. in 1901. This construction has again come to the front in the case of the English-built Parsons turbine, purchased by, but not yet delivered to, the Commonwealth Edison Co., of Chicago. It is new, however, to employ high-pressure and low-pressure elements driving separate generators, each at a different synchronous speed.

When any turbine is designed for high expansion ratios the engineer is confronted with the problem of having to deal with relatively minute volumes of steam at the high-pressure end and enormous volumes at the low-pressure end. It is therefore evident that if the high-pressure portion of a turbine may be operated at twice the rotative speed of the low pressure, this problem is largely eliminated.

Besides the gain from using different speeds, the division of the turbine into two separate elements has other advantages. The temperature range in either element is reduced. A sufficient number of stages may be introduced to give high hydraulic efficiency without any mechanical difficulties, such as increased length between bearings, etc. Some little advantage is also to be gained by separating the water between the two turbine elements which has been precipitated in the steam expansion. Either element is more reliable and simple because of its smaller size. Doubtless there is some loss of efficiency due to the employment of two generators instead of one at twice the capacity, but this is more than overbalanced by the gain in economy, due to the two elements operating at different speeds. For want of a better term these units have been called "cross-compound" machines.

It is planned to carry a vacuum of 29 in. on the turbine and 120 deg. of superheat. The steam-consumption guarantee provides for 75.75 per cent. of the energy available in the expanding steam materializing as electrical energy at the terminals of the generators.

Igard Water-Glass Shield and Reflector

The Igard water-glass shield and reflector is designed to protect the firemen from flying glass and escaping water and steam, when working in the proximity of a water column. It consists of four split castings, which clamp to the bodies of the gage-glass cocks. These castings are grooved, allowing the shield, which is made in two parts, to travel in their respective grooves.

The shield, which is manufactured by the Gardner Grate Co., 27 Burgess St., Boston, Mass., when open, allows a view of the gage-glass from any position in the room in front of the boilers. When closed, two-thirds of the circle is covered, leaving one-third open to the rear for the escape of the flying glass, steam and water.

The inside of the shield is of flat-white enamel, with a red line down the center, which enables the attendant to see the waterline instantly. The apparatus is finished in brass or nickel, and is made to fit any water

Power Plant of Springfield Street Railway Co.

By W. O. Rogers

YNOPSIS—This power plant supplies electrical energy to operate approximately 175 miles of street railway. The generating units are in two rooms and consist of vertical and horizontal cross-compound engines, directly connected to 600-volt, direct-current generators. Water-tube boilers are used, with mechanical stokers.

Next to the central-lighting plant, the power plant f the Springfield Street Ry. Co. is the largest in the ity of Springfield, Mass. This station supplies elecrical energy for approximately 175 miles of track. It s said that a greater percentage of the inhabitants atronize the trolley lines than in any other city in he United States, based on the population of each.

As is frequently the case, this power plant is comosed of two sets of installations, those of the original oilers and engines and a newer section in which larger nd later-designed units have been installed.

The plant is built near the Connecticut River, but separated from it by the tracks of the N. Y., N. H. & H. R.R. Condensing water, also boiler-feed water, can e had for the pumping. The older section of the plant s a comparatively low brick building, in which are onsed eight water-tube boilers, which carry 150-lb. team pressure. These boilers are placed in a boiler oom adjoining the end of the old engine room, Fig. 1, nd are set with the rear ends toward the wall separatng the boiler and engine rooms. Six of the boilers re set on one side of a brick stack which is 175 ft. igh, with an inside diameter of 8 ft. The two remaining boilers connect with the stack from the opposite ide. The boilers are fired by mechanical stokers, six f which are driven from a shafting suspended above he boiler setting and driven by a vertical steam engine. The two other stokers are driven by a separate engine and shafting.

Coal and Ash

Ashes are removed by hand from the ashpit into an ash cart and carried on an elevator to a level with the ash bin, built on the outside of the new boiler house. The ashes are dumped into the bin and are carted away by the city free of cost.

Coal is unloaded from railroad cars into a hopper, built under a spur track, and is elevated to a tower and then dumped into a small industrial coal car, and after weighing is carried to the coal bin above the boiler in the new boiler house. A chute permits of dumping fuel into a bunker in the yard from which it is admitted

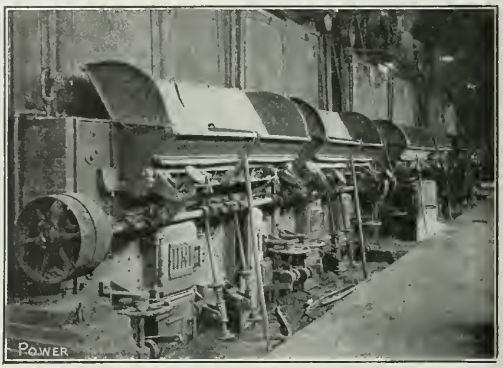


Fig. 1. Boilers in Old Boiler Room

Fig. 2. New Boiler Room

Fig. 3. One of the Vertical Engines

to the old boiler room through openings in the wall facing the boilers.

New Boiler Room

In the new boiler room, Fig. 2, there are eight 350-hp. water-tube boilers with a working pressure of 150 lb. They have gravity underfeed stokers, driven by chains and sprockets indirectly from four sets of turbine-driven blowers. The blowers are belt-connected to line shafts which are suspended from the basement ceiling. By this arrangement as the speed of the blowers is reduced with an increase of steam pressure, the feeding of fuel to the furnace is retarded. With a decrease of steam pressure the speed of both fans and stokers is increased.

Ashes are removed from the ashpits into an ash can in the basement and are then hoisted on an elevator to the ash bin already mentioned.

All blowoff pipes are connected to one large blowoff main back of each row of boilers. The pipes are placed beneath the concrete flooring with the valve stem of the blowoff valves in a vertical position, the handwheels only coming above the flooring.

These boilers are connected by smoke flues from the back end to a 225-ft. brick stack with a 10-ft. inside

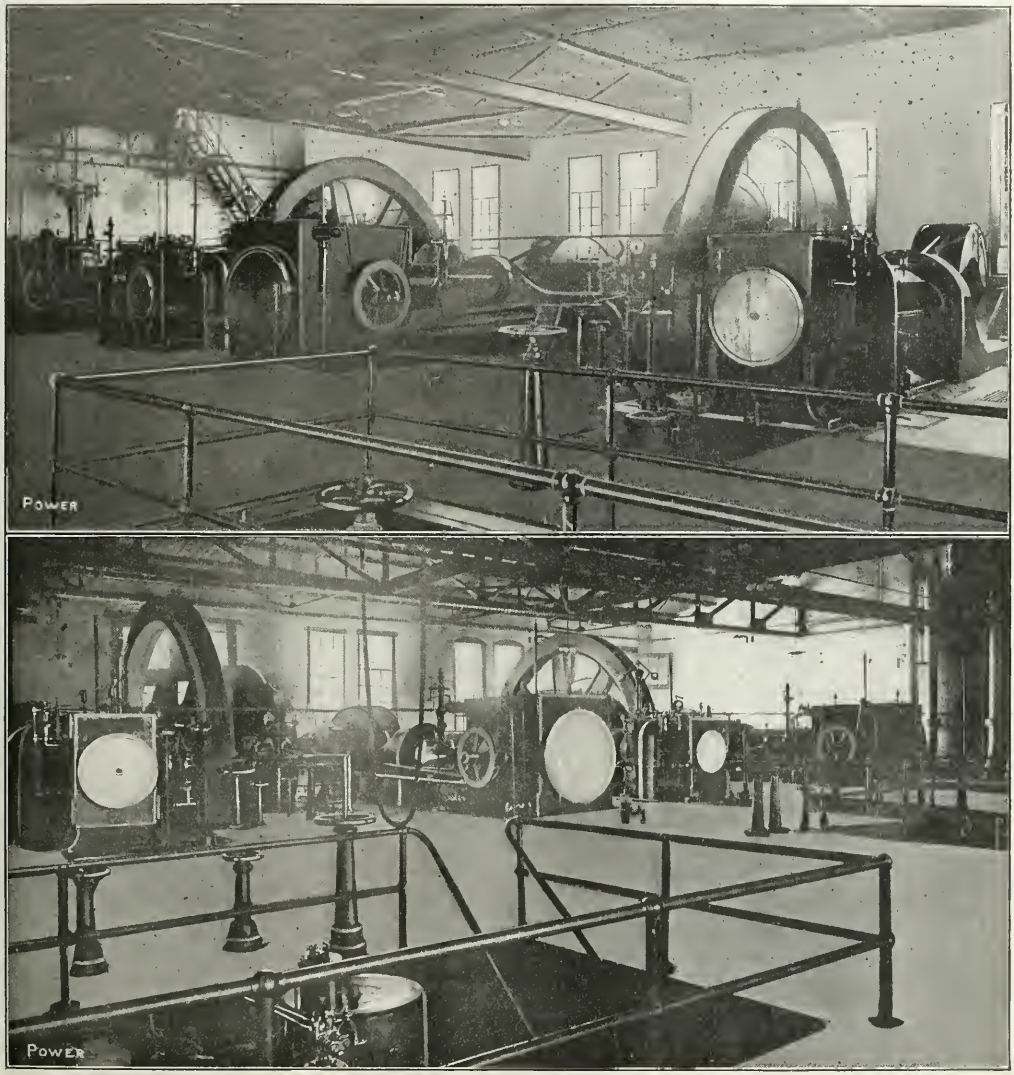


Fig. 4. Two Views of the Old Engine Room

iameter. It is built at the end of the boiler house at ıe end of one row of boilers, which necessitates run- ing one smoke flue across the boiler room. The gases f combustion pass through two economizers on their ay to the chimney.

Engine Rooms

In the old engine room, Fig. 4, there are four cross- ompound engines running condensing. Each is directly onnected to a multipolar, 600-volt generator, running at 0 r.p.m. These units are placed two on each side of ıe engine room, leaving the floor space in the center vailable for condenser pits and stairways leading to the

PRINCIPAL EQUIPMENT OF THE SPRINGFIELD STREET RAILWAY CO.'S POWER PLANT.

No.	Equipment	Type	Purpose	Volts	Amp.	Hp.	R.p.m.	Steam Pressure Lb.	Size	Manufacturers
8	Boilers	Water Tube	Steam Generators			250		150		Babcock & Wilcox Co.
8						350				
8	Stokers	Acme	Boilers							Harrisburg Foundry & Mach. Co.
4		Taylor								American Engineering Co.
2	Engines	Corliss	Main Units				80	150		
4	Economizers	Green	Feed Water							Green Fuel Economizer Co.
4	Generators	Direct Current	Main Units	600	1333		80			
1	Condensers		Corliss Engines						12x25x18"	International Steam Pump Co.
1	Condenser	Jet	Vertical Engines					150	18x44x24"	Blake Pump & Condenser Co.
1										Warren Steam Pump Co.
1	Engine	Vertical Comp.	Main Units				75		38x76x60"	Westinghouse Machine Co.
1		Direct Current							38x78x60"	McIntosh & Seymour Co.
1	Generator			600	3478	3300				
						3300				General Electric Co.
2	Converters	Rotary	Alt. Current	600	500		500			
				380						

asement. All engines run condensing and exhaust team pipes are attached to four 12 and 25 by 18-in. et condensers. An 18 and 44 by 24-in. jet condenser perates with each of the two large vertical cross-com- ound engines in the newer part of the plant. One of he units is shown in Fig. 3. These four-valve engines ave 38 and 76 by 60 and 38 and 78 by 60-in. cylin- ers. Each is directly connected to a 600-volt railway enerator at 75 r.p.m.

Two rotary converters are operated in the old engine oom. The alternating-current side is 25-cycle, 380 volts t 500 r.p.m., the direct-current being 60 volts and 500- mpere capacity.

Technical Extra Illustration

By A. L. Haas

A friend of the writer's greatly interested in litera- ure, uses a simple scheme for classifying his quite con- iderable knowledge about books. He takes a number f literary journals and papers from which articles he s particularly interested in are cut out as soon as read. Loose clippings, being especially difficult to find when anted, he pastes at appropriate places in his books. He as a number of crowded shelves, the contents of which ear mainly on a definite period and a particular phase f literature.

As an intimate of his, the writer has been lent many of is treasures. Money simply could not buy them, they re annotated, marginally penciled, interleaved and nderlined. Parallel passages are easy to compare. The nserted clippings and illustrations amplify the text normously. Every book this friend possesses has more han one short biography of the author stuck in.

If a criticism by a reviewer appears in a current eriodical or newspaper about any book this man pos- esses, it is pasted somewhere in that book. If an author nentions a particular place, a magazine illustration or a ostcard, if procurable, is stuck in.

This practice was started as a consequence of reading an article on grangerizing or extra illustration, and it was decided that clippings on any subject matter are as relevant as pictures—sometimes more so, so he uses both.

The average engineer owns a good many technical books, at the same time he is forced to scrap quantities of reading and advertising matter in the current techni- cal publications. Why not preserve the best of the latter in extra-illustrating the technical books?

In most all of such books the publisher has left a splendid scrapbook at the end in a catalog of other publications. These, with the usual flyleaves, and exclud- ing contents and index, leave available several pages to use, besides the numerous spaces at ends of chapters.

Books are greatly enhanced in value by extra illustra- tions and clippings. Take one on steam engines for an example of the method. The author has made a selec- tion of types, each machine illustrated being typical of its particular class which does not exhaust the field. From the advertising pages of current periodicals a number of illustrations can be taken to amplify the text. If an engine is referred to but not shown, the next picture of it that is met with can be stuck in along one edge at the most convenient place. Of great advantage is the fact that the material compiled by the author is section- alized and carefully arranged by him. No thought is needed on the part of the extra-illustrator as to the arrangement; it is already arranged.

Discrimination is needed especially in the matter actually pasted in, but obsolete matter is easily removed without destroying the actual book, if the clippings are pasted along one edge only to the margin of the page.

It is even possible to graft essential matter from one book into another, making two volumes into one, where only a small amount of relative importance is found in one of the two books of similar subject.

The books on the shelf form a convenient receptacle for the loose pieces of paper, and even when loose they are where they belong. When inclination and leisure serve, the slips are already in place, need no sorting out, and a few minutes with a paste brush suffice to fix them permanently.

As a variation or extension of pasting in, pockets can be formed of glazed linen and glued inside the covers at either end with their mouths to the back of the book.

Books of quite trivial value when extra-illustrated with taste and care with prints; even if the pictures are not particularly scarce or rare at the time of such amplifica- tion, have realized, after a lapse of years, quite consider- able prices to collectors. It is possible that technical books thus treated may be found to have an added value some time in the future.

Purchasing or Making Power

By Henry D. Jackson

YNOPSIS—A case is cited where the operating costs e much too high, the labor exceeding the fuel cost. comparison of manufactured and purchased power vors the isolated plant.

The question of purchasing or making their own power constantly before engineers who are confronted with e statements of power-company representatives, as to eir reasons why power should be purchased from them ther than generated in the plant under consideration. ne of the latest arguments coming to my attention is ven herewith.

There was a plant whose product demanded a 24-hour rvice. The average motor load would approximate 75 v.; the maximum, 100 kw. The power-plant engineer ated that a duplicate outfit of 100 kw. normal capacity ould be installed to insure continuous service instead two 75-kw. machines, which could easily handle this ad, as these machines are capable of handling a 50 r cent. overload for two hours and could handle a 33 r cent. overload continuously.

There are many plants where 24-hour service is deanded for six days each week with a single unit, and more trouble is experienced than would ordinarily had with a duplicate unit. It only requires careful tention and good apparatus. In many cases a duplite unit is not necessary; but, if so, it is not necessary duplicate the boilers and other apparatus.

According to the figures obtained, the labor for the 00-kw. plant cited is $5840. One man could act as both gineer and fireman. The coal figures $5500 per year d the labor exceeds the cost of coal. The total cost is 4,390, including the fixed charges on the generating paratus.

In the case of purchased power, the total charges ainst the plant are the cost of power, which at 1½ nts per kilowatt hour is equal to $9750, an apparent ving of $4640. Against this purchased power there no charge for superintendence and care of the equipent, which is evidently included in the labor charge hen power is generated. Since the motor equipment is e same in both cases, no charge is made against this making the comparison. But in either case heat will required, so that a fireman would be necessary during e winter months and his labor charge should be added the case of purchased power, also the heating coal.

In addition to this, there are the boilers and the fixed harges on these, so that this $4640 does not represent net saving, but a saving of a fictitious character, or e difference between the cost of power furnished in ie case, and the cost of power, superintendence and eat, with all fixed charges included, in the other case; ., with the plant generating its own power.

So far as possibility of interruption to the service is ncerned, it would be necessary to install a duplicate nk of transformers and other outside protection, to sure the purchaser against loss of power from the lightg company, as the chances of the generator or engine nit giving out are no greater than are the chances of ie transformers being burned out from some cause.

If a plant averaging 75-kw. capacity cannot produce power for less than 2.24 cents per kw.-hr. when there are 650,000 kw.-hr. generated during the year, there is something wrong both with the installation and in the manner of operation.

When power plants are installed under such conditions and comparisons are made between them, and the question of purchasing power on such a basis, it is not unnatural that the cost of power in the industrial plants should be high, and it is just such plants which make it possible for the central station to get in its service. It is not fair to the industrial-plant owner to get or accept any recommendations when it cannot be shown that the cost of heat, light and power, in the case power is purchased, is less than the cost of heat, light and power when he generates it himself.

Power is not the sole item of consideration. Heat, particularly in the northern latitudes, is of as much importance as power, and it is frequently found that the cost of coal for heating is practically equal to what it would cost for the power, if the heating system is properly laid out, and that, therefore, this item of coal can frequently be eliminated during the heating season and the only charges to be made against the power are the added interest charges for the larger boilers, power-plant installation, oil, waste, etc., with such additional labor as may be necessary to operate the engine plant in addition to the heating plant. During the summer season, all coal must be charged up against power.

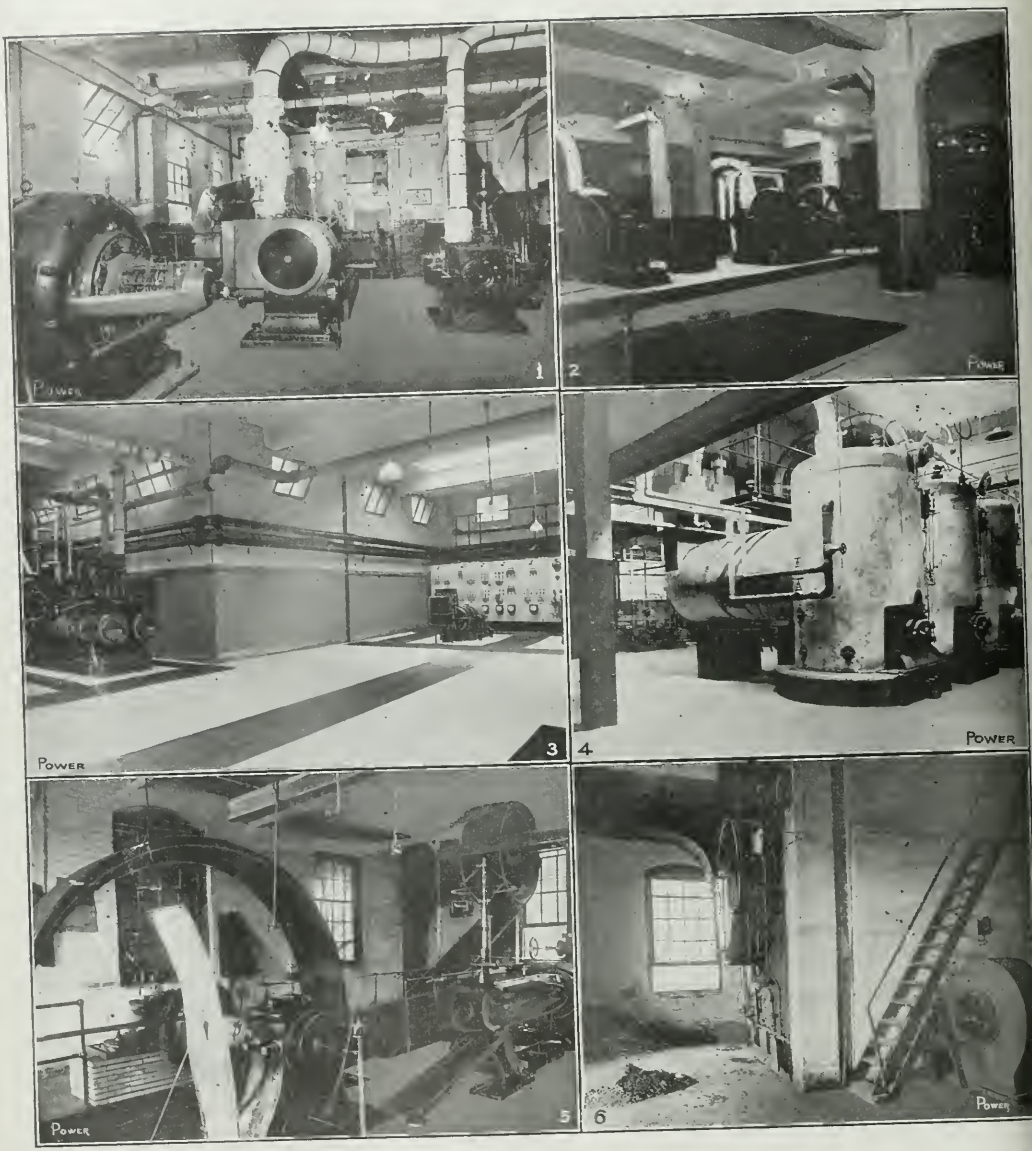
New Rotary Power Pump

A new line of rotary power pumps, in which gear-style cams have been substituted for the three-toed cams, has been placed on the market.

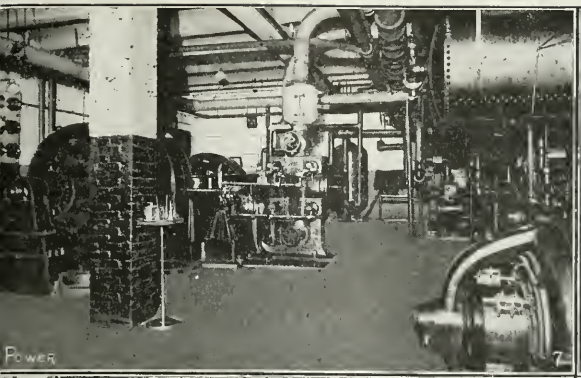
Two sizes are built by the Goulds Manufacturing Co., Seneca Falls, N. Y. One has a capacity of 25 to 50 gal. per min., running at 225 to 450 r.p.m., and the other has a capacity of 50 to 100 gal. per min., running at 225 to 450 r.p.m. Both pumps are suitable for pressure up to 100 lb. or 230-ft. elevation.

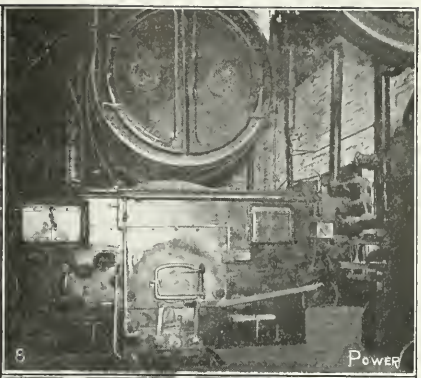
They are mounted on a cast-iron bedplate, fitted with an outboard bearing and tight and loose pulleys for belt drive. The suction connection is made within the base directly beneath the case, and is reached through hand holes in the base. The smaller pump has two discharge openings, one tapped for a pipe, the other threaded for a hose coupling. The larger pump has three discharge openings, two fitted as in the small pump, and the third fitted with an interchangeable blank flange.

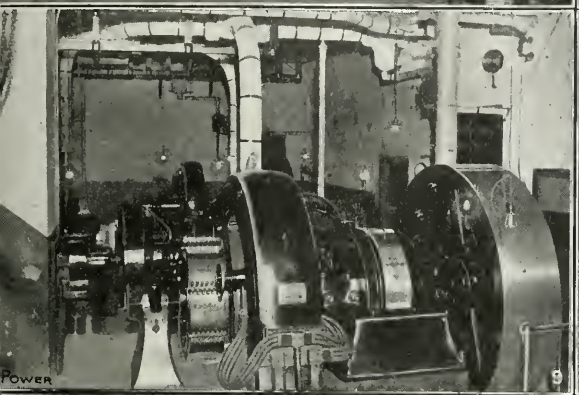
Oklahoma Coal Output in 1912 Larger Than Ever—The total production of coal in Oklahoma in 1912, according to E. W. Parker, of the United States Geological Survey, was 3,675,418 short tons, having a value at the mines of $7,867,331. These statistics have been compiled in coöperation with the State Geological Survey. The record of 1912 exceeded that of the previous maximum output (in 1907) by nearly 33,000 tons. Compared with 1911, it showed a gain of 19.6%, in quantity, and of 25% in value. The reason for the increased activity in 1912 appears to be the diminution in the supply of natural gas and fuel oil in the markets tributary to Oklahoma coal.

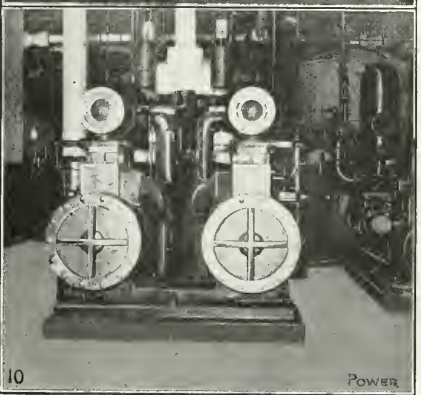


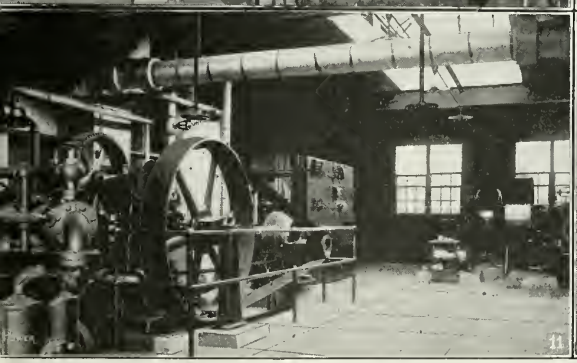
SPRINGFIELD, MASS., WHERE THE NATIONAL CONVENTION OF N. A. S. E. WILL BE HELD NEXT WEEK, IS SOMEWHAT OF A MANUFACTURING CITY. A FEW OF THE POWER PLANTS OF THE FACTORIES, OFFICE BUILDINGS AND DEPARTMENT STORES ARE ILLUSTRATED HEREWITH IN FIGS. 1 TO 12, INCLUSIVE. FIG. 1 IS THE ENGINE ROOM OF THE KNOX CO., MANUFACTURERS OF KNOX AUTOMOBILES. THE LARGE ENGINE DRIVES THE DIRECT-CURRENT GENERATOR SHOWN IN THE FOREGROUND. FIG. 2 IS A PARTIAL VIEW OF THE ENGINE ROOM OF THE MYRICK BUILDING, COMBINED OFFICE AND POWER BLOCK. FIG. 3 SHOWS THE ELEVATOR PUMPS AND ONE OF THE TWO MOTOR-DRIVEN GENERATORS AT THE CENTRAL FIRE STATION. FIG. 4 IS A VIEW OF THE BOILER ROOM OF THE SAME PLANT. THE PUMPS ARE FOR ELEVATOR SERVICE, AND THE GENERATOR SETS SUPPLY CURRENT FOR ILLUMINATING THE ADJACENT BUILDING AND TOWER. ELECTRICAL ENERGY IS PURCHASED AT PRESENT FROM THE CENTRAL STATION, BUT ENGINES AND GENERATORS WILL BE INSTALLED EVENTUALLY. FIGS. 5 AND 6 ILLUSTRATE THE CORLISS ENGINE AND RETURN-TUBULAR BOILER OF THE BARNEY & BERRY CO., MANUFACTURERS OF SKATES.

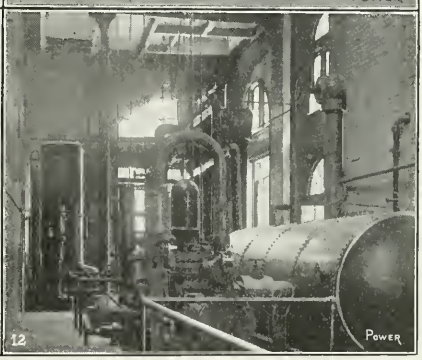












In Figs. 7 and 8 Is Shown a Partial View of the Engine and Boiler Rooms of the Massachusetts Mutual Life Insurance Building, One of the Finest Buildings in the City. The Engine Room Is Typical of the General Run of Office Buildings, but the Two Boiler Installations Are Interesting, Owing to the Method of Placing the Furnaces, which Are Built below the Horizontal Shell of the Fitzgibbons Boilers. As the Furnaces Are of the Dutch-Oven Type, Equipped with Mechanical Stoker, Quite a Saving of Space Has Been Made. The Engine Room of Forbes & Wallace, One of the Large Department Stores, Is Shown in Figs. 9 and 10. The Generators Are for Lighting Service. The Pumps for Elevator Operation. The U. S. Envelope Co., Envelope Manufacturer, Generates all Electrical Energy Used, in the Engine Room Shown in Fig. 11. The Absorption Refrigerating System, Fig. 12, Is at the Eastern States Refrigeration Co. The Pumps, Boiler, Etc., Are on the Ground Floor and But a Partial View of the Plant Is Shown.

ELECTRICAL DEPARTMENT

Switchboard Signaling in the World's Largest Power Station

In the world's largest power house, the Keokuk generating station of the Mississippi River Power Co., it is more than 800 ft., or nearly one-sixth of a mile, from the switchboard to the most remote generator, and no part of the generator room is visible from the switchboard because the latter is installed in an upper story. For this reason, no efforts were spared to make the signal system as dependable as possible.

Transmitters and receivers are installed on each benchboard, the number corresponding to that of the generator controlled by it, and also one receiver and transmitter are placed beside each generating unit. The left-hand dial of each switchboard set is the transmitter, while the upper dial of the pedestal set is the corresponding receiver at the generator. The lower dial of the pedestal set is the generator attendant's transmitter, while the right-hand dial in the switchboard set is the corresponding receiver.

The transmitter of the switchboard set is operated by means of a handle, pointer, and dial mounted on the front of the benchboard and concentric with the handwheel which operates the field rheostat of the corresponding generator. The pointer of the corresponding receiver in the generator room instantly points to the same signal.

The synchronous motion of the pointers of the transmitter and receiver is secured by means of small induction motors, each provided with a three-phase delta-connected stator winding and a single-phase rotor winding of the shuttle type, the windings being exactly alike in all the machines, and corresponding dials having their signals at exactly the same points with respect to the winding.

Motors for corresponding transmitters and receivers have their stator windings connected in multiple but not excited except by induction from the rotor winding. The rotors are also connected in multiple and are excited from a single-phase source. With two motors connected thus, any motion of the rotor of one is accompanied by a corresponding motion of the rotor of the other. Thus each will always bear the same relative position to its stator winding. In sending signals, the rotor of the transmitter is turned so that the hand pointer on the dial points to the signal it is desired to send and the rotor of the connected machine or machines instantly moves around so that the hand on the dial of the receiver also points to the same signal.

The rotors are excited from a 25-cycle, 125-volt circuit with provisions for automatically throwing them across an auxiliary supply circuit in case of failure of the main supply.

Double push-button switches are located on both sides of the transmission handles, and serve to operate signal lamps, whistles and bells.

To send a signal, the switchboard operator turns the handle to the signal he wishes to send, this action moving the pointer on the dial of the transmitter, and, consequently, the pointer on the dial of the receiver at the generator stand, so that they both point to this signal. He then pushes a button on the right of the transmitting handle, thus lighting a lamp on the generator whose operator is being signaled to and also blowing a whistle to attract his attention. As soon as the operator at the machine has read the signal, he turns the handle of his transmitter to the same signal, thus transmitting the signal he has received back to the switchboard operator as a check. Then he presses the button at the right of his transmitting handle, thus extinguishing the lamp and cutting out the whistle; after which he presses the button at the left of the handle so as to light a lamp in the switchboard room and ring a bell there to attract the attention of the switchboard operator, who, after checking the signal, presses the button at the left of the transmitter handle, extinguishing the lamp and cutting out the bell. This completes the sending and checking of a signal.

The devices for sending and checking signals as outlined above were manufactured by the General Electric Co.

Two Cases of Hunting

We have two 200-kw., 440-volt, alternating-current generators, direct-connected to 12x24x30-in. cross-compound Allis-Chalmers engines, which refuse to run in parallel. These engines are fitted with Harting governors and run at 150 r.p.m. The exciters are belt-driven from the flywheel of the main units and are compound wound. The switchboard is fitted with a synchroscope and the machines go together perfectly, but in the course of 10 to 30 sec. hunting sets in and gradually gets worse. The speed regulation of the units individually appears to be good. Any suggestions as to the probable trouble would be appreciated.

A. N. Kerr.

Las Vegas, Nev.

We have one 100-kw., three-phase, 2300-volt, 60-cycle generator, direct-connected to a simple engine of the high-speed Corliss type, and one 75-kw., 2300-volt, three-phase, 60-cycle unit direct-connected to the same type of engine. The 100-kw. machine has 32 poles and runs at 225 r.p.m. The 75-kw. machine has 28 poles, and runs at 257 r.p.m. Both are of the revolving-field type. They will come together all right, but soon hunting sets in, so that one has to be cut out of the line, and the smaller machine will not carry the night load. What can be done to prevent this trouble? The exciters are connected to an equalizing busbar and there is an equalizing rheostat on the switchboard.

V. K. Stanley.

Ponca City, Okla.

Trouble with Three-Wire Generators in Parallel

In a certain plant, there were two 200-kw., 220-volt, three-wire direct-current engine-driven generators in the original installation, and two 150-kw. turbine-driven units of similar type were installed later, to take care of the increase in the load. The neutral of the three-wire generators was taken from collector rings, as low-frequency alternating current, and the direct-current neutral tap was taken from the middle of the balance coils. All of the machines were compound wound, with the series fields divided so that equal compounding would be developed from each side of the circuit. The two 200-kw. engine-driven generators were eight-pole machines, with four series field coils on each side of the circuit, while the two 150-kw. turbine-driven generators were four-pole machines, having two series field coils on each side.

As long as the load remained fairly steady, the generators operated properly, but as the load changed, an attendant would have to watch the machines very closely, and any sudden fluctuations always resulted in trouble. The two turbine-driven generators would operate in parallel with each other very satisfactorily, but would not operate properly in parallel with the engine units. Numerous changes were made in compounding and in governor adjustments, both on the engine and turbine units, but without much apparent success.

The load recently increased to a point where the turbines had to be operated in parallel with the engines, or be discarded, and as the exact trouble had not been located, a detailed study was made of the conditions before condemning the machines. A careful test was made to make certain that the compounding was correct, using a water barrel to create the load, testing each machine separately, and the machines were left over-compounded 10 volts, as the builders' specifications called for. It was then observed that when the turbine-driven generators were disconnected from the line, after being in parallel with the engine-driven generators, their voltage instantly dropped from the normal voltage of 240 to a point as low as 40 or 50 volts. This was an indication that the series fields had been carrying an undue amount of current, causing the generators to partake largely of the character of series generators and resulting in faulty electrical regulation.

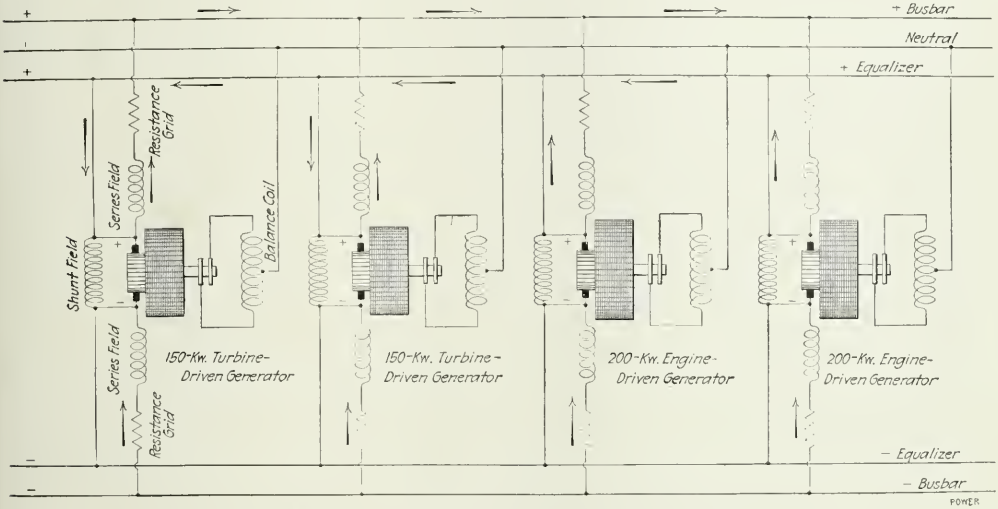
Seeking the cause of this, it was found that on account of the extreme difference in speed, and the number and size of poles, the series field circuits in the turbine-driven generators had only about one-eighth the resistance of those on the engine-driven generators, causing nearly all of the current generated to flow through the positive equalizer and series coils of the turbine-driven generators to the line, as shown by arrows on the sketch, increasing the effect of the series fields enormously.

Ammeters were used to determine the amount of current, and the excess was often nearly 100 per cent. of the normal rating. It was impracticable to reduce the resistance of the series field coils on the engine-driven generators, which would have been a little more efficient, so the resistance of the turbine-driven generator series fields was increased by the use of heavy cast-iron resistance grids, mounted so that they could be added or removed until the proper amount was inserted in the circuit. These grids were so designed that there were no serious losses, and the heating was scarcely noticeable.

When this work was completed the machines operated in parallel without any trouble, and permitted the load to be carried on any combination of generators desired.

H. R. Mason.

St. Louis, Mo.



Connections of Three-Wire Generators in Parallel

The electricity supplied in the city of London is in the hands of thirty-one separate enterprises, part of them, including the largest individual outputs being private corporations and the rest municipal enterprises by the various Borough Councils. It is said one can find single-phase systems at 50 and 85 cycles and the three-phase systems at 50 and 25 cycles, and both alternating current and direct current, three-wire systems at all voltages.—Edison Current Topics.

GAS POWER DEPARTMENT

Work at Sulzer Bros. in Switzerland

Three years ago the editor visited Sulzer Bros., at Winterthur, expecting to see the latest and best in steam-engine building. They had not made a large engine there in several years; steam engines are only built at the Ludwigshafen Works. It was all steam turbines and Diesel engines. This year he found that they had abandoned the making of the steam turbine also, and have pinned their faith, so far as power-producing apparatus is concerned, to the Diesel engine. They have brought to its development all the skill and experience in design and workmanship which gave this shop in the Swiss mountains a world's record with its steam engines, and are working out the internal-combustion motor in large sizes scientifically and systematically. They believe it has a large future in the marine field, especially if the number of cylinders can be reduced, and have built purely for experimental purposes a single-acting two-stroke-cycle engine having a cylinder some 40 in. in diameter, 44-in. stroke and running at 165 r.p.m., with which they have developed between 1600 and 1700 hp. in a single cylinder, and out of which they hope eventually to get 2000 hp. If this can be done the powering of even a large and fast steamer will be quite practicable, considering that the boilers and condensers are done away with and less space would be required for the fuel.

They have perfected a reversing gear with which the engine is handled as positively and easily as a steam engine, and the valve gear, outside of the starting mechanism, is reduced to the fuel valve and auxiliary scavenging ports above the exhaust slots in the cylinder, closing them during the expansion stroke but holding them open during the return stroke and lengthening the period for scavenging and exhaust. The engine is tied together by four massive rods between the top cylinder head and the bed, relieving the cast-iron cylinder and guides from the longitudinal working stress. The maximum pressure upon the piston is some 300 metric tons.

One of the successful boats fitted with Sulzer-Diesel engines is the "Monte Penedo," of the Hamburg-South American Line, which has made a successful voyage from Hamburg to Buenos Ayres and back and has lately arrived in New York from another South American port. She is a 6000-ton freighter and makes about 10 knots with two 2-cycle single-acting engines of 850 hp. each.

We saw upon the floor two Diesel engines for United States torpedo boats. It was somewhat surprising to see, way up there in the mountains, miles from any water which it would navigate, a 200-ft. steamer on the ways. These boats are built in considerable numbers, fitted with engines and boilers and everything but the woodwork and sent to the Swiss lakes. The one which we saw was a side-wheeler with 1000 hp. and was going to Lake Geneva.

All this does not mean that the bulk of their power work is marine. They have built and are building many good-sized Diesel engines for stationary work, a recent delivery being a 6-cylinder engine to drive a 2500-kw. alternator for the A. E. G.

We have referred before to the excellence of their boiler work. An extra bending roll is used to avoid the tangential edge left by the three-roll process. The bent sheet is then stood endwise upon a face-plate, the edges are planed vertically and brought together, the butt straps bolted on, perfect circularity assured, and then all the holes are drilled through the butt straps and the sheets, no punching being used anywhere in the process. We saw a boiler shell 8.5 ft. in diameter and 9.5 ft. long made of a single sheet.

Centrifugal pumps is another of their products, and they are handling heads of 2000 ft. with eight stages.

One department of the works is devoted to heating boilers, radiators and heating apparatus, which they manufacture in great quantities. They have a number of installations in which the exhaust of Diesel engines is used for heating purposes.

⁂

New Method of Cooling Gas Engines

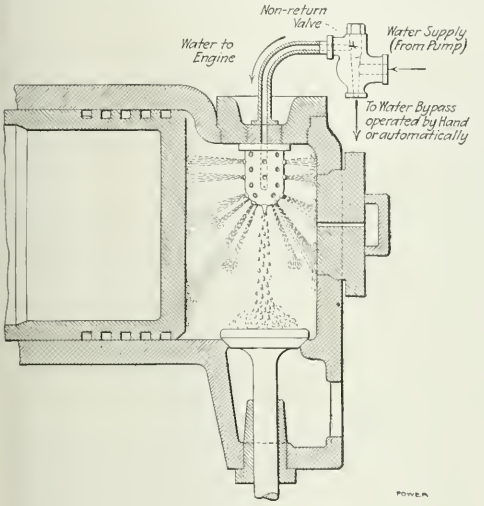
In a paper read before the Institution of Mechanical Engineers, at Cambridge, on July 29, Prof. Bertram Hopkinson, who, for many years, has been engaged in research in connection with gas-power plants, described a new method of cooling the cylinders and pistons of gas engines.

Ordinarily about 30 per cent. of the heat value of the fuel passes from the hot gases to the cylinder walls and pistons. In order to prevent the overheating of these parts under test conditions, it is necessary to provide a water jacket around the cylinder, and, in the case of large engines, to circulate water through the pistons and around the exhaust valves. Most of the disadvantages under which the gas engines labor are due directly or indirectly to this fact. The complicated and thick-walled castings required for the cylinders are apt to crack under the influence of the wide variations of temperature, and overheating of deposits on the internal walls of the combustion chamber causes pre-ignition, so that it is not always practicable to work a gas engine continuously at its maximum output.

The idea of introducing water into an internal-combustion engine is not new. It is a common practice in oil engines to introduce water along with the oil in order to permit the compression to be raised, and water has been injected into gas engines for the purpose of preventing preignition. Proposals have also been made to introduce water for the purpose of cooling parts of the metal. None of the latter, however, have been practical, if indeed they have ever been more than just proposals on paper, apparently because their originators did not appreciate the conditions which must be satisfied with the injected water to act as an effective cooling agent. If the water be turned into steam before reaching the metal it will not exert any cooling effect, except indirectly by

lowering the temperature of the flame, and such lowered temperature is accompanied by a considerable loss of efficiency. On the other hand, water which reaches the walls in liquid form and is there evaporated, absorbs out of the heat given to the walls by the gas the whole of its own heat of evaporation, and there is no loss of thermodynamic efficiency, because the heat used is waste heat, which, in a jacketed engine, would go to warm the cooling water.

The author claims that it is of no use to inject the water in a fine spray, or to introduce it into the gas or air pipe, so that it is carried in suspension in the incoming charge, or, as is often done in oil engines, to spray it in along with the oil. Although some of these devices have proved useful for the prevention of preignition and for the softening of the explosion, none are effective for the purpose of cooling.



Section through Head of Cylinder, Showing Water Jets

The author found, however, that by injecting water in comparatively coarse jets against the internal surface of the cylinder, and the head of the piston, the metal can be kept cool without materially cooling the gases, with the result that there is no loss of efficiency. The temperature of the parts can be perfectly controlled, and simple single-walled castings can be used for the cylinders.

Experiments of Dugald Clerk, the author, and others have shown that the rate of heat-flow from the gas into the metal is far more rapid at and soon after the instant of ignition than at any other time. It seems likely from these experiments that for practical purposes the heat flow into the barrel of the cylinder during the last three-fourths of the expansion stroke might be so small compared with that in the first period that direct cooling of this portion of the cylinder could be dispensed with altogether. This anticipation has been found correct, and it has been found necessary only to direct the spray against the walls in the combustion chamber, and the piston, the rest of the cylinder being kept cool by conduction. Cold water is injected through a hollow casting projecting into the combustion chamber and provided with a number of nozzles or holes about $\frac{1}{32}$ in. in diameter, from which the jets are projected against the metal surfaces.

For the purpose of experiment, an 11½x21-in. Crossley engine, rated at 40 hp., was fitted with a new cylinder consisting of a plain barrel without a water jacket. A section of the cylinder is herewith shown. The injection rose is a hollow casting projecting into the combustion chamber and provided with 25 holes, as shown. The drip from the rose suffices to cool the exhaust valve. A simple plunger pump driven by a cam injects a charge of water once in a cycle, lasting from about 30 deg. before to 30 deg. after the point of ignition, during which period practically the whole of the sliding surface of the barrel is covered by the piston. The quantity of water used was about 2.4 lb. per brake horsepower-hour, and the temperature of the engine ranged from 150 to 180 deg., C. The engine consumed about 15 cu.ft. of coal gas per brake horsepower-hour, both when it was water-jacketed and after being fitted with the new cylinder.

Tests at other loads showed that with a weak mixture the gas consumption is slightly increased by the water injection, but with very rich mixtures it is a trifle less. The difference, however, does not exceed 5 per cent. either way, and on the average it may be said that the economy is unaffected by the use of this method of cooling.

This engine was set to work driving a dynamo, and its speed was increased from 180 to 195 r.p.m., when it was found capable of developing 50 b.hp. for many hours, an increase of 25 per cent. on its original maximum safe load. It has now been running for a total period of 5000 hr. on regular work, giving no trouble at all, and the combined wear on both cylinder and piston is less than 0.01 in.

To regulate the water supply in accordance with the load the pump is connected to the governor, which is of the hit-and-miss type, so that the pump only takes a stroke when the engine takes gas.

With a throttle governor a corresponding regulation is easily provided. A simple thermostat has also been devised, which automatically controls the supply of water during starting and when the engine is running, quite satisfactorily.

In case of failure of the water supply, nothing happens except that the engine slowly heats up, and after ten minutes or so, preignitions occur, bringing the engine to a standstill. No damage results from this, but to guard against any possible danger a fusible safety plug is screwed into the combustion chamber, which melts if the cylinder gets too hot, and the noise of the escaping gases warns the attendant.

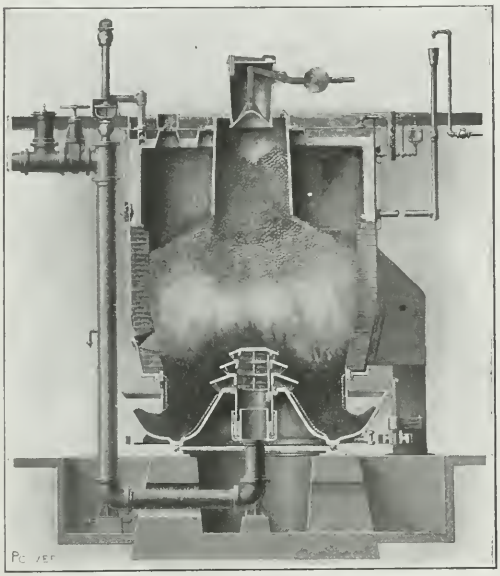
The system has also been applied to an engine of 105 hp., and to one of 1000 hp.; in each case the original cylinder was used, without water in the jacket. The large engine was run under load 30 hr. without a stop; after a short stop for adjustments, it ran for 70 hr. without a stop, driving a factory, and developing an average of 800 hp. The whole of the injection apparatus for the 1000-hp. engine cost only $100, and within a few hours of putting it on the engine it was doing all the work of the cooling tower, centrifugal

pumps, etc., previously used. An 18x24-in. two-stroke-cycle single-acting engine has been built for use with the new system, and is now undergoing trials.

New Gas Producer

In the May 27 issue we described at some length the Illmer two-stroke-cycle gas engine—a product of the Reading Iron Co. More recently, however, this company has taken up the producer end of the problem and has developed a producer for use with either anthracite or bituminous coals.

As shown in the illustration, this producer while representing nothing radically new, nevertheless, combines a number of the well recognized points of good design.



Section through Reading Producer

Perhaps the most important feature is the agitation of the fuel bed by a rotating water-sealed ash tray, thus tending to eliminate blow holes by a twisting action through the hottest part of the combustion zone, and at the same time continually removing the ashes.

A uniform blast distribution is attained by having the blast tuyeres consist of three separate hoods which rotate with the ash tray. The passages from the central-blast pipe to the hood chambers are contracted so as to maintain the same blast pressure to each chamber. The vaporizer forms the upper part of the producer and the blast saturation is automatically controlled by a thermostat in the blast pipe.

A rachet drive actuates the ash tray at a slow speed—several revolutions per hour; and the tray is so designed as to permit any of its parts being replaced without disturbing the stationary shell.

For bituminous coal installations a cooling tower and mechanically operated gas scrubber are furnished. This scrubber is of the centrifugal type and carries a two-stage rotor consisting of a pair of spaced disks provided with radial blades on both sides of each disk. The casing is divided into two communicating compartments, each of which encloses one of the bladed disks, thus forming two independent stages for the tar extraction. A set of nozzles at each stage directs the water spray toward the rotor blades.

Splash Lubrication

In the July 29 number Mr. Westwood tells how he cut down the oil bill on a vertical gas engine $300 per year by lowering the oil level in the crankcase and adding a pump to his splash-feed system.

Now, it seems to me that the great beauty of the splash-oiling system is its simplicity and reliability. Therefore, if possible, it should be adjusted to distribute the oil properly without recourse to such complications as pumps, piping and feed cups. Instead of lowering the oil level in the crankcase I like to raise the level until the bearings have copious streams of oil pouring through them. Then I cut down the amount of oil that splashes up into the cylinder by baffles made of sheet metal. One may usually be placed across the lower end of the cylinder with a slit across it for the connecting rod to work in. This slit should not be made too small as the air below the piston has to flow back and forth between the cylinder and crankcase at every revolution of the engine. If this baffle is not enough, others may often be placed on the connecting rod, traveling up and down with it, sometimes below and sometimes above the stationary baffle. In one place, where I could not place baffles at any of these points, I fastened one to the piston, hanging it several inches below the lower end of the piston, with a slit in it for the connecting rod.

I probably am something of a crank when it comes to splash lubrication, as I have even used it on a horizontal engine. It worked very well, but there were so many baffles that an agent of the makers thought someone had been putting junk in the engine for the purpose of wrecking it. This engine ran "over"; I have never tried it on an engine running "under."

Fred Boone.

Davidson, Okla.

Peat Production Small

While the United States is the richest country in the world in the deposits of peat, little active work is done in mining or digging it. So far as is known very few of the peat-fuel plants established have gone beyond the experimental stage and many of them have never been equipped with essential machinery.

Reports from all known peat-fuel plants in the United States, according to an advance chapter from "Mineral Resources, 1912," on the production of peat in 1912, by Charles A. Davis, show that with one exception they were idle during the summer of 1912.

The output of peat fuel was reported as about 1300 tons, valued at $4550. All this peat was sold. A copy of the report on peat may be obtained free on application to the Director, U. S. Geological Survey, Washington, D. C.

REFRIGERATION DEPARTMENT

Ammonia Condensers

By Fred Ophuls

Several new types of open-air ammonia condensers have recently been put on the market with certain claims of superiority, and it appears not untimely to say a few words on this subject. There are four distinct classes of ammonia condensers and these again may be subdivided into several types, each varying in their general arrangement and in the relative directions of flow of the cooling water and ammonia.

Before studying the effect of the design and construction on the efficiency of operation during each of these separate periods a brief description of the various types will be given. Only those types and designs most commonly used will be considered.

Condensers Classified

Ammonia condensers may be classified as follows:

Open-air or atmospheric condensers—Flow of water perpendicular to the flow of ammonia. (a) The water and ammonia flowing in the same general direction. (b) The water and ammonia flowing in general in opposite directions, commonly called counter-current type. (c) A combination of types (a) and (b).

Double-pipe condensers—Flow of water parallel to flow of ammonia. (a) Counter-current type. (b) A combination of counter-current flow and flow in the same direction.

Surface condensers—(a) Spiral-coil types. Flow of water perpendicular to flow of ammonia. (b) Straight-tube types. Flow of water parallel to flow of ammonia either counter-current or a combination of counter-current flow and flow in the same direction.

Submerged condensers—(a) Spiral-coil types. Flow

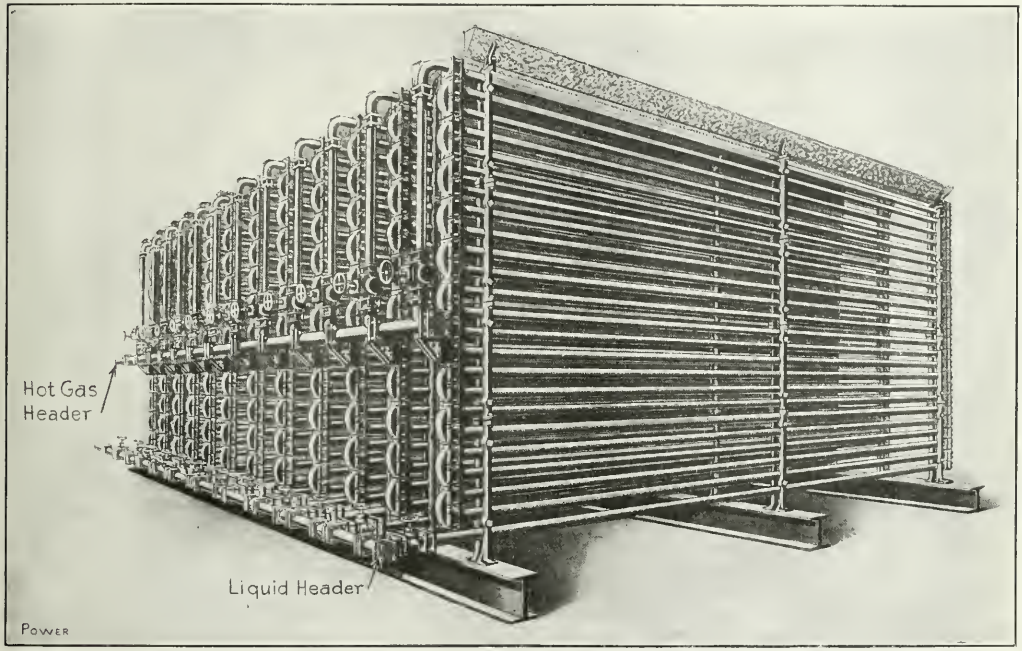


Fig. 1. A Large Type (a) Atmospheric Condenser

The function of an ammonia condenser is to cool and liquefy at the lowest economical pressure the compressed ammonia vapors discharged into it. The work done in the condenser can be divided into the following distinct periods:

1. Superheat period, during which the sensible heat of the vapor is removed, that is, the temperature of the superheated vapor is reduced to the temperature of liquefaction.

2. Liquefaction period, during which the latent heat is removed, that is, the vapor is liquefied.

3. Liquid forecooling period, during which some sensible heat is removed from the liquid, that is, the liquid is cooled below the temperature at which it is liquefied.

of water perpendicular or parallel to flow of ammonia. (b) Straight-coil type. A combination of parallel and perpendicular flow.

Figures 1 to 11, inclusive, are illustrations of the most common designs of these various types. In this issue only atmospheric condensers will be considered, but the other three classes will follow in a later issue.

Open-Air or Atmospheric Condensers

Type (a) condenser, illustrated in Figs. 1 and 2, consists of one or more vertical stands of pipe coils, each made up of either 24 or 18 two-in. 20-ft. lengths of pipe placed horizontally and joined into one continuous coil by means of return bends. The ammonia in the form of vapor enters each coil at the free end of the top pipe and leaves condensed into a liquid at the free end of the bottom pipe. This construction requires that the hot ammonia vapor comes in contact with the cooling water at its lowest temperature and the liquid ammonia leaves at the point where the water has attained its maximum temperature. These conditions of operation do not produce the lowest liquefying pressure and lowest final temperature of the liquid.

Due to this condition efforts have been made to design an open-air condenser making use of, at least to some extent, the counter-current principle.

In Fig. 3 is shown a counter-current condenser (type (b)), which fulfills most of the requirements of economic operation. This condenser is of the same general construction as the condensers above described, but the hot ammonia vapor enters at the free end of the bottom pipe

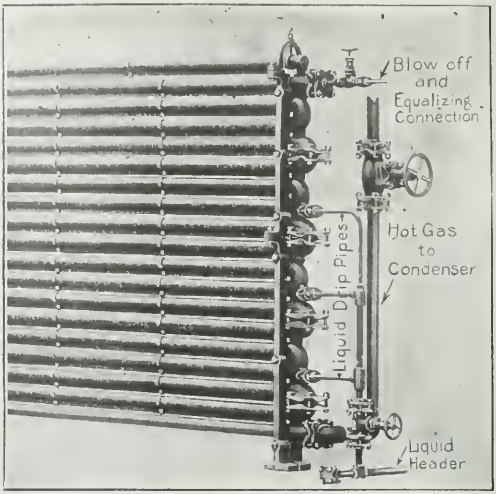


Fig. 3. An Atmospheric Condenser of Counter-Current Type

and by means of liquid drip pipes, attached at the fourth, eighth, twelfth and sixteenth pipes from the bottom, for the coils 24 pipes high, and at the fourth, eighth and twelfth pipes for the coils 18 pipes high, the liquid is drained off practically as soon as it forms, so that most

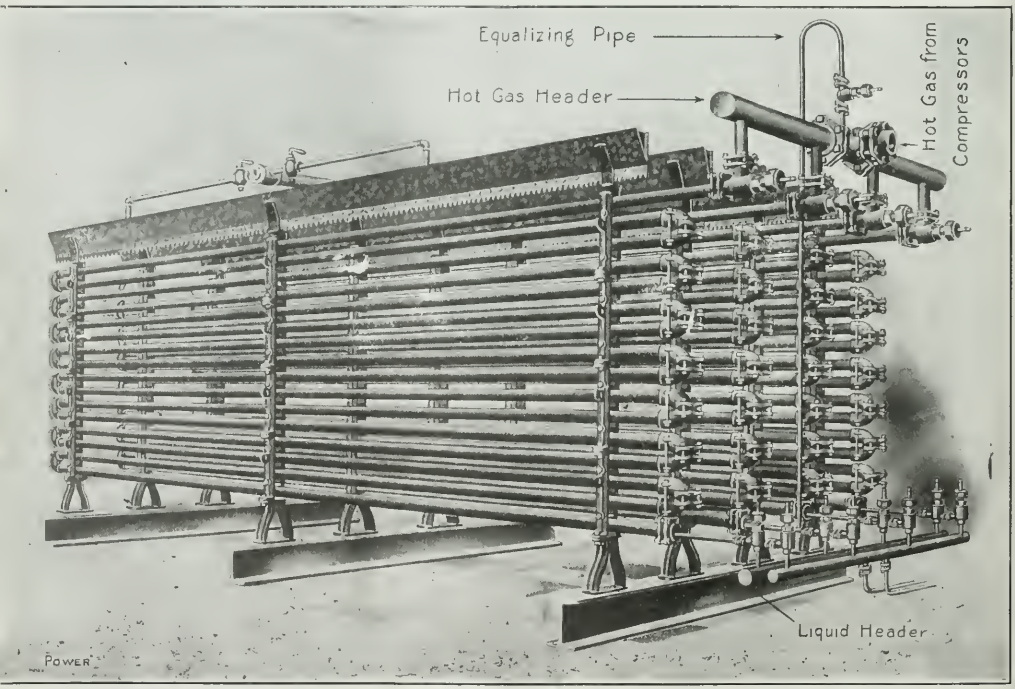


Fig. 2. Another Atmospheric Condenser of the Same General Type as Fig. 1

of the pipe surface is available for liquefying purposes. This arrangement of the ammonia and water currents brings the condensing water at its initial temperature in contact with the liquefying vapor and the hottest water with the cooling vapor.

Fig. 4 illustrates another type of counter-current open-air ammonia condenser, in which the ammonia vapor enters the free end of the bottom pipe and the liquid ammonia leaves at the free end of the top pipe. This type was recently designed and constructed by Louis

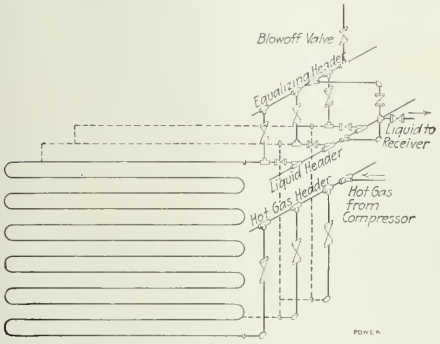


Fig. 4. Open-Air Ammonia Condenser, Block System

Block, consulting engineer. In these condensers all the liquid ammonia condensed must be forced upward by the current of the ammonia vapor so that it can be discharged from the top pipe. This requirement is entirely opposite to the principle adopted for the design embodied in the condenser shown in Fig. 3.

Type (c) condenser, a combination of types (a) and (b), was constructed with the idea to offset, at least to some extent, the disadvantages of type (a). From Figs. 5 and 6 it will be seen that the hot ammonia vapor enters at the free end of the bottom pipe and flows up through the lower two or three pipes respectively, and is then brought by means of a vertical riser into the top pipe. The purpose of this construction is to remove the vapor superheat in the lower pipes and liquefy the vapor as it flows down through the upper pipes, the liquid finally leaving at the ends of the third or fifth pipes from the bottom, respectively. The purpose of the ejector *A*, shown in Fig. 6, will be explained hereafter.

Ammonia in Brine

In Power of July 8 there was a short article on the effect of ammonia in calcium-chloride brine when used in a refrigerating system. My experience with brines of all classes leads me to feel that while the general trend of this article is correct it may be somewhat misleading, for the reason that there are on the American market several chlorides which in name are called calcium chlorides, whereas in fact they are mixtures, mechanical or otherwise, of at least two and generally three chlorides, namely, calcium chloride, magnesium chloride and sodium chloride, in varying proportions according to the brine from which they are crystallized. The action of ammonia on a straight calcium-chloride product is not the same as on one of these mixed-chloride products when they are dissolved in water to make brine.

Calcium chloride is not precipitated from brine by the addition of ammonia, whereas magnesium chloride is

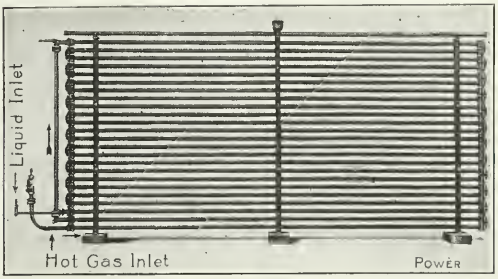


Fig. 5. Atmospheric Condenser, Type (c)

precipitated in amounts varying with the conditions attendant. Under ordinary conditions sodium chloride is not precipitated by the addition of ammonia. In this matter we are chiefly concerned with the relative behavior of calcium chloride and of magnesium chloride toward ammonia, either gaseous or in solution in water.

In the article, of which this is a discussion, the statement is made that when ammonia gets into a calcium-chloride brine that, unless the ammonia content becomes sufficiently high to keep down the amount of calcium chloride which will dissolve in the given amount of water, there will be no bad effects, in fact the freezing point of the brine will be somewhat lowered.

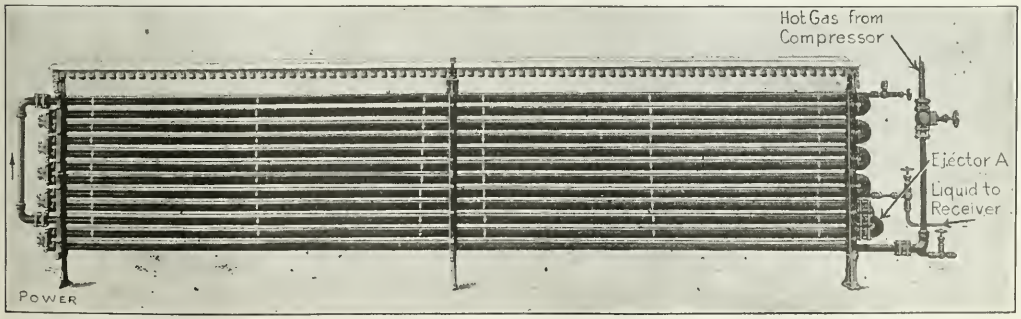


Fig. 6. Another Design of Type (c) Condenser

In the case of mixed-chloride brines, according to my experience, ammonia at once precipitates out of solution the magnesium chloride which in this reaction is converted to magnesium hydroxide. The result of this action is the reverse of that noted above in the case of a straight calcium-chloride brine, for with the loss of magnesium chloride from the brine the freezing point actually rises. When this occurs a sludge is formed in the brine, in amount proportional to the amount of ammonia which has entered into the brine. If this sludge is of sufficient amount, with the corresponding rise in freezing point, as has been the case in several instances of which the writer is cognizant, it has happened that the whole circulating system for the brine has become clogged and in at least one case pump heads have been forced off on this account. Needless to say, there is also the danger of a heavy sludge forming in the bottom of the brine tanks, an occurrence likely to cause much difficulty in the operation of the plant.

For a more definite treatment of this subject the writer would refer the reader to an article, written by the writer, appearing in *Ice & Refrigeration*, Vol. 42, No. 2, p. 91, February, 1912, which gives quantitatively the results of passing ammonia gas into brines of the following description: Each brine was of a strength equivalent to 1.2 sp.gr. at 23 deg. C. Distilled water was used in each case to dissolve the chlorides.

1. Brine made up with chemically pure calcium chloride.

2. Brine made up with chemically pure magnesium chloride.

3. Brine made up with a commercial straight calcium chloride containing no magnesium chloride, but with something like 1.5 per cent. sodium chloride.

4. Brine made up with a commercial mixed-chloride product containing the three chlorides, calcium, magnesium and sodium, the original chloride containing 53.90 per cent. calcium chloride, 12.12 per cent. magnesium chloride and 0.43 per cent. sodium chloride, the remainder being water of crystallization.

When ammonia was passed into these brines no precipitation took place in the case of brines 1 and 3, whereas in the case of brines 2 and 4 immediate precipitation took place. Under certain conditions fully 97.5 per cent. of the total magnesium chloride in brines 2 and 4 was precipitated out of the solution in the form of a heavy, white sludge.

Considering the character of the brines used in these tests, there can be no question with regard to the different behavior of ammonia toward them, the brines affected by the addition of ammonia being in each case those which contain magnesium chloride. As noted above, ammonia does not, except in the presence of carbon dioxide gas in excess, precipitate sodium chloride from solution.

MORGAN B. SMITH.

Detroit, Mich.

Log Sheet for Ice Plant

The writer offers herewith a daily log sheet that will provide a detailed statement of the practical operation of a compression can-ice-making plant. Keeping such a record stimulates the engineer to his best efforts and the list of daily records soon becomes a valuable reference by which past and present operation may be compared. The records also furnish the management with the details of operation and the conditions existing in the plant. More confidence will be placed in the engineer who furnishes such reports. For his own benefit as well as the general welfare of the plant, every engineer, no matter how small the plant, should keep some record of the daily operation.

New York City. M. J. ELLSWORTH.

DAILY OPERATING SHEET ---------- 191

HIGHEST TEMPERATURE OBSERVED ---------- WEATHER CONDITIONS

STEAM BOILERS				REFRIGERATING MACHINES				STEAM CONDENSERS				WATER TEMPERATURES	
No.	Started	Stopped	Hr. Run	No.	Started	Stopped	At R.P.M.	No.	Started	Stopped	Hr. Run	Boiler Feed	
1				1				1				Storage Tank	
2				2				2				Filter Water	
3				3				3				Cooler Water	
4				4				4				River Water	
5					Total Machine Tons				Total Condenser Hr.			Condensing Water	
6					Condenser Pressure				Condenser Vacuum			Condenser Discharge	
	Total Boilers Hours				Back Pressure				Exhaust Line			Liquid Ammonia Line	

No.	River Pumps		Hr. Run	No.	Evaporators		Hr. Run	No.	Generating Units		Hr. Run	METER READINGS	
1				1				1				City Water	
2				2				2				Boiler Feed	
3				3				3				Lighting	
	Total Pump Hours				Total Evaporator Hr.				Total Machine Kw-hr.			Power	

ICE TANK TEMPERATURE AND TIME RECORDS

Tank Nos.	Time 6 A.M. to 6 P.M. Temperatures											Amount of Ice Pulled	Amount of Ice In Tank
	6	7	8	9	10	11	12	1	2	3	4	5	
1													
2													
3													
4													
12													
13													
14													

Tank Nos.	Time 6 P.M. to 6 A.M. Temperatures												Amount of Ice Pulled	Amount of Ice In Tank
	6	7	8	9	10	11	12	1	2	3	4	5		
1														
2														
3														
4														
12														
13														
14														

NO. ROW STARTED		NO. ROW FINISHED		NO. ROW STARTED		NO. ROW FINISHED	
Cleaning Boilers	NO.	Water Filters Washed	NO.	General Remarks			
Cleaning Economizer		Water Coolers Washed					
Cleaning Condensers		Filter Lines Washed					
Cleaning Evaporators		Discharge Lines Washed					
Cleaning Cake Filters		Deoderizers Washed					

Chief Engineer

POWER

EDITORIALS

Progress in Gas-Engine Design

The new method of cooling gas engines, devised by Professor Hopkinson and described elsewhere in this issue, deserves close attention in view of the important bearing it may have upon the future of the gas engine. The success which has been attained with this system, in an engine of one thousand horsepower, which was not even specially designed to suit the new conditions, indicates that the costly castings hitherto required for the cylinder, as well as the elaborate provision for cooling and circulating the cooling water, might as well be dispensed with: a simple single-walled cylinder will suffice, and the piston will require no internal circulating water. Moreover, the speed and output of the engine may be materially increased. All these factors combined would apparently reduce the cost per horsepower by perhaps twenty-five or thirty per cent., thus at once bringing the gas plant into keen competition with the steam plant as far as first cost is concerned.

The system can hardly be regarded as in the experimental stage, since a forty-horsepower engine fitted with Professor Hopkinson's cooling device has already run for five thousand hours under ordinary load conditions, and was found to be in no way adversely affected by the application of the cooling water to the interior of the cylinder.

The gas plant, when working under favorable conditions, can already show remarkable results in running costs. The increased reliability conferred upon it by the new method, which practically eliminates the risk of cracked cylinder heads and wreckage of the engine due to a failure of the cooling-water supply, will remove one of the most weighty objections to its adoption.

It should be observed that this new development is not a chance discovery, but the fruit of prolonged investigation and research on scientific lines. Professor Hopkinson is a son of Dr. John Hopkinson, whose splendid work in laying the foundations of scientific dynamo design insured him a place in technical history.

Negligence of Elevator Operators

Engineers of experience in office buildings having hydraulic elevators know of the many troubles occasioned by the carelessness of operators. In large buildings the situation is aggravated by the operators usually being under the direction of the janitor. The chief engineer having no authority over them cannot properly discipline them when they are guilty of carelessness. The janitor, knowing little or nothing about machinery, cannot appreciate to what extent his operators' carelessness causes damage and makes unnecessary work for the engineering department.

A favorite trick with many operators is to depend upon the automatic to stop the car at the top floor instead of using the control lever. Usually it works, but there are times when it does not, and then there is a collision with the overhead works and more or less serious damage is done.

It is useless for any of the engineering force to attempt to catch operators depending solely on the automatics by riding with them to the top floors. They do right when watched. But the negligent ones may easily be detected by observing the pilot valves and the governor cables at the bottom of the shaft.

One company owning a group of office buildings having a total of about forty elevators has created an elevator department separate from the engineering department. The head of this department is responsible for the operations of cars, repairs of all elevator machinery except the pumps, and has charge over all the operators. In a card system, each operator has a card on which is recorded the date and nature of every accident to the car he was operating at the time and whether or not he was responsible for the accident. Careful operators whose habits are commendable receive more pay than those who are less attentive to their duties.

The results of the new system are indeed gratifying. There is no more friction between the janitor and the chief engineer or elevator foreman, and overhead collisions because of failure to stop with the operating lever are very rare.

Similar systems might be adopted in other office buildings, hotels, department stores, etc., with good results.

Cincinnati Smoke Rules

After considerable study and investigation, the Boiler, Furnace and Stack Code Commission of Cincinnati has handed in its report, as told on page 349 of this issue.

Like many of the Middle Western cities, Cincinnati is troubled with the emission of objectionable smoke from the furnaces of steam boilers, stationary, locomotive and marine. Unlike many cities, Cincinnati has appreciated that smoke abatement is an engineering problem. Engineers are doing the work that requires engineering talent instead of leaving it to a health, building, or some other incompetent department.

The proposed rules (perhaps adopted by the Council since we went to press) give the Smoke Inspection Department authority to supervise the construction of all boiler furnaces and require alterations to furnaces not in operation if such are necessary. The smoke-density indicator is good when used correctly and equitably, a thing not done by most authorities responsible for the enforcement of city smoke ordinances.

We would recommend to such authorities and to the Smoke Inspection Department of Cincinnati, the manner of determining when a stack becomes a nuisance, that is followed by the Smoke Inspection Department of Chicago:

Instead of holding as a nuisance a stack which emits smoke of No. 3 or 4 Ringelmann chart for a stated time,

establish a "smoke unit" system (see POWER, page 202, Aug. 6, 1912). Otherwise owners of a chimney emitting smoke of say, No. 2 Ringelmann density for ten hours, thus producing a great amount of smoke, will not be within the law, while owners of stacks emitting smoke of No. 3 density for a short time only could be prosecuted. Most any central-station plant will produce objectionable smoke for short periods when quickly disturbing the banked fires to meet the suddenly great load fluctuations due to summer showers, etc.

In the smoke-abatement movement that is becoming so widespread there is one fact that engineers should emphasize. That is, that when burning many if not all grades of bituminous coal under usual operating conditions, it is impossible to obtain actual smokeless combustion. It should be made clear that with care and proper furnaces, combustion of such coal will produce smoke, but of a density and volume that is not objectionable.

Citizens, ignorant of the problems of smoke abatement, believe statements by some engineers or *pseudo* engineers that "absolutely smokeless combustion is possible," and the most unreasonable demands are made of the smoke-inspection authorities and owners of boiler furnaces.

Boiler Tube Failures

A recent tube failure in an almost new water-tube boiler serves as a reminder that such accidents are a source of constant danger. A recognized authority recently stated that the loss of life and limb exacted by tube failure in water-tube boilers probably exceeds that due to any other class of boiler accident.

The particular failure here mentioned resulted in the death of one man and the serious injury of another. The boiler, of the box-header type, was one of three in a modern office-building plant and had been in service less than 18 months. Two boilers were in service at the time of the accident, which occurred at 3 o'clock in the afternoon, while the third was out for cleaning. The boilers are equipped with chain-grate stokers and the boiler room is arranged with two floors, one at the usual level, a few feet below the grate level, and another immediately beneath, for receiving and handling the ashes. The tube which failed was the fifth from one side and in the bottom row. The failure occurred about 30 in. from the front end and on the bottom side of the tube; the rupture was about 14 in. long. Part of the liberated steam forced its way down through the grate into the ash room while the balance came out into the fire room. An automatic non-return valve prevented the other boiler on the line from emptying its contents.

Of the two men on the firing floor one escaped by hurrying into the engine room, the doors of which were closed as quickly as possible. The other ran up a ladder and escaped into a tunnelway, suffering, however, a rather severe scalding before he could get out of range. A third man was at work in the ashroom and his only means of exit was a ladder which extended up through the fireroom to a floor above. He got part way up this ladder, but as conditions in the fireroom were as bad as in the ashroom he was overcome before he could reach safety. He was taken out as soon as help could reach him and died in a hospital a few hours later.

The opinion unanimously entertained by the boiler manufacturer, insurance company's inspector and the city boiler inspector is that the failure was caused by the presence of oil on the surface of the tube, preventing the water from conducting the heat away rapidly enough. The lips of the rupture were almost as sharp as a knife edge, indicating that the tube had been greatly elongated circumferentially before the break developed. The high ductility thus shown precludes suspicion of a defect in the tube itself.

The investigation following the accident brought out the fact that the oil separators apparently had not been operating effectively and that the presence of excessive oil in the boilers was known. One boiler had been thoroughly cleaned, the second was being cleaned, and the third, the one in which the tube failed, was to be cleaned as soon as possible.

While oil is by no means the only cause of tube failure, it certainly is an important one. And the regrettable feature of failures due to this cause is that they could all be avoided by the reasonable use of preventive means. A good filter to supplement the customary oil separators is a splendid insurance against trouble from oil getting into the boilers. Regular inspection of the apparatus provided for extracting the oil and, above all, thorough inspection of the interior surface of the boilers should be considered cardinal duties by every engineer. Because a tube cleaner does not gouge out great piles of scale when it is run through the tubes it does not necessarily follow that the boiler is in an economical and safe operating condition.

The fact that every tube failure does not result fatally encourages the impression that such failures are of but minor importance. And, perhaps, this point of view tends to heighten the danger through neglect of precaution, a condition resulting from contempt bred of familiarity.

Besides oil, another fruitful source of failure is inherent defects in the tube which ordinarily are undiscoverable. It is well known that a defective weld seldom shows on the surface. Besides, even when surface indications are present, the chances of discovery are small because a large proportion of the tubes are beyond the reach or vision of the inspector. Careful inspection at the shop, although unsatisfactory at best, is about the only precautionary means against accidents due to defectively welded tubes.

Although seamless tubes offer freedom from danger due to this source, they have the disadvantage of not always being of uniform thickness. With the cold-drawn tube, it is said that internal strains are produced which sometimes cause the tube to break simply when heated. Annealing practically eliminates this tendency.

Then, numerous tube failures occur without the slightest apparent cause. A welded tube will frequently break elsewhere than at the weld and without being corroded or weakened in any apparent manner and without evidence of overheating. Possibly these causes which cannot be foreseen tend to increase carelessness with regard to detecting and eliminating those that are discoverable. At any rate, there is no doubting that if all manufacturers and all plant operators would exercise greater precaution, the number of accidents would be markedly reduced. Their present frequency is appalling.

READERS WITH SOMETHING TO SAY

Cause of Defective Diagrams

The diagrams, Figs. 1 and 2, were taken from a 10x12- automatic engine, initial pressure 80 lb., and running 0 r.p.m. The scale of the indicator spring was 40. After taking Fig. 1 the valve was taken out and filled h water, which showed that it leaked in the port or

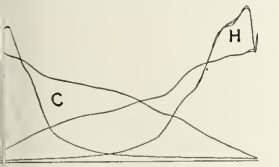


FIG. 1

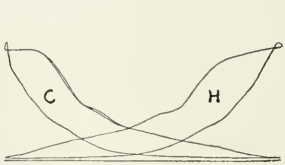


FIG. 2

Diagram from Engine with Leaky Valve

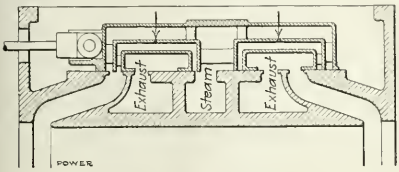


Fig. 3. Type of Valve That Leaked

xhaust-steam passage. After a new valve was put in and b diagram, Fig. 2, taken, the back of the old valve was ded down. Large blow-holes were then visible, their ation being indicated by the arrows, Fig. 3.

Grand Rapids, Mich. James Boetsma.

Repaired Scored Valves and Valve Seats

In the plant where I am employed we have an 11x14- n high-speed, riding-cutoff, shaft-governor engine that a been in service 20 years, 20 hr. per day, 365 days per e, and is still giving good service.

Last winter this engine began to run at dangerous pds. It was not safe to throw off the load unless we de a jump for the throttle at the same time. Indicator a s at no load showed late enough cutoff on the head n to cause the engine to run away.

After examining the governor adjustments, valve rod n rocker-arm and finding nothing wrong the steam h t was examined and a broken rib on the cutoff valve va found, which caused the valve to spring and the leak- g of steam was sufficient to lift the valve from its seat n admit enough steam to the head end of the cylinder o roduce a dangerous speed at light loads.

The broken valve was repaired by the oxyacetylene- ding process and scraped to a tight fit, after which the ngine ran at normal speed.

One week later the main valve started a continual la ming. Upon examination of the valves, the other rib of the cutoff valve was found broken, due, no doubt, to the strains thrown upon it when the first rib broke. It was also found that chips from the broken rib had worked under the main valve and badly cut the valve face and seat. It took three days of hard work to scrape and fit the main valve and seat, and put in a new cutoff valve.

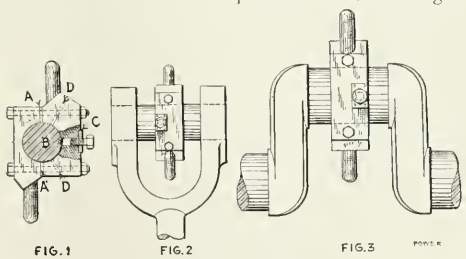
All engineers were cautioned to use plenty of cylinder oil until the freshly scraped valves and seats were worn to a polish. At this time the feeding of the lubricators bothered by slowing up, due to a very heavy grade of cylinder oil being used. Everything went smoothly for three days when a careless employee allowed the lubricators to slow up, or perhaps stop entirely, and the seats were again badly cut, the first intimation being a slamming of the main valve, due to steam rushing under it and lifting it from its seat.

It took three more days and part of three nights to again refit the main valve. This incident leads me to believe that there are many engines damaged by lack of sufficient cylinder oil, due to the neglect and carelessness of the men intrusted with their care.

Estherville, Iowa. E. C. Sutton.

Truing Crankpin by Hand

A planer that is handy for quickly turning down pins that are worn out of round is shown in Fig. 1. This device is of great value when there is not time to send the pins to a machine shop. It is made of two pieces of hard wood bolted together, with $\frac{1}{16}$-in. liners inserted at *A* and bored to fit the largest place on the pin. The handles are cut out of the pieces of wood forming the



Planer and Its Application to Pins

blocks, and the length of the handles and width of the block must be made suitable for the job undertaken. A hole is cut in the block at B to take a ½- or ⅝-in. tool; square steel is preferred, and is to fit the hole snugly. A plate is set in the block at C drilled and tapped to fit a ½- or ⅝-in. setscrew and set nut to feed the tool.

Two oil-holes at *D* should have stoppers so that the oil cannot run out when the "planer" is turned. The blocks should be bolted together very solidly and just bind slightly on the pin. The tool should have a lip,

with very little clearance, and set down so that a very light cut is taken while plenty of oil is kept on the pin. Turning down a pin in this way is much easier and quicker than filing a pin and makes a good job if the liners are removed as occasion requires to keep the block close to the pin. We had six crosshead pins of the type shown in Fig. 2, which were badly worn, and at every port at which we stopped for a short time, one was taken down and turned off with one of these planers until all were in good condition. A splendid job was also done on the port high-pressure crankpin, Fig. 3, which was 16 in. in diameter. When turning these "planers" a slight pressure in the direction that the tool is to cut, will act as a feed, and with a little practice as smooth and nice a cut will be taken off as one would take on a lathe. Care must be taken to prevent too many shavings from getting under the wood. This can be prevented by having the tool near the edge and just enough offset on it so that it will cut at the edge of the block.

Philadelphia, Penn. K. D. GRANT.

Safety Valve Sticks

When we started our new plant we had one boiler in commission and we raised the pressure to 125 lb., at which the safety valve opened as desired. The valve would not close, however, until the steam pressure had decreased nearly 50 lb.

Investigation revealed that the bushing at the top of the valve through which the steam passed was too snug a fit and when the stem and bushing became heated by the steam, the stem became fast and stuck until it contracted enough to move. By making the stem hole in the bushing a trifle larger the trouble never recurred.

New Westminster, B. C. C. J. WILKE.

Preparing for a Peak Load

Upon taking charge of a new plant, I have found it was customary for the fireman to provide against a peak load by having a pile of coal handy and the fire clean of ash. Usually the draft is open, there is a thin fire on the grates and the boiler setting is allowed to become cool. These conditions are more generally found if the prevailing load is light.

Lowering of the boiler pressure, due to unusual demands for steam, is usually the first and only warning to the fireman that the peak load has been added.

He then throws open the fire-doors and fires heavy and, if the draft of steam continues, he finds the steam pressure continues to drop and his efforts are generally rewarded with little success in holding up the steam, unless he is relieved of some of the load long enough for the boiler-furnace walls to become properly heated for combustion to continue with temperature sufficient for the increased load.

Such conditions result in complaints of plant management and, in turn the firemen complain of shortage of boiler capacity. The time when peak loads may be expected is generally known and I believe I have met with considerable success in overcoming the difficulties in carrying heavy fires in anticipation of peak loads.

My method is first to provide a stack-damper gearing which is within convenient reach of the fireman for him to set the damper to different notches or points of open ing, ascertain by flue-gas analysis the thickest fire tha can be carried on the grates which will yield good eff ciency with dampers wide open. Then, to meet a suc den demand for this full capacity, and meanwhile hav the best combustion attainable, the firemen are instructe to keep their grates covered evenly with good solid fi of the thickness required for carrying the full overloac and regulate the draft according to the intermediate de mands.

When the overload comes on, there is then no undu opening of fire-doors; no chilling effect of stoking gree fuel—or, in fact, of stoking any green fuel for some tim after the dampers have been thrown wide open, and regu lar firing for the peak load is begun and continued with out interruption.

It is true that, after waiting for the peak load wit dampers partly closed and carrying a thick fire, CO_2 ma rise as high as 16 per cent., and there may be a rise i percentage of carbon monoxide and a drop in the eff ciency. This, however, will be only temporary for, wit most favorable conditions present, the highest efficienc is soon recovered.

Employing a CO_2 recorder during the regular workin load, it is soon ascertained what rate of firing and ope ing of damper are most favorable to economy. Then b stoking and operating the damper appropriately for th rate of combustion necessary to keep up steam for th regular working load, and observing the indication of th CO_2 recorder, it is soon learned how to hold the regula load with best economy while thus prepared for a pea load, and while certainty and economy in carrying th peak load are assured, very fair economy may be thus at tained for the intervals between peak loads.

Timmer, N. D. T. E. GRIFFITH.

Fire-Clay Furnace Arch

A furnace arch, which may help out in an emergency or where the furnace fires are not driven hard, may b constructed of a mixture of cement and fire clay. Mak a form of two boards of the desired height, fastene together at the ends with strips of wood. Cut two arc pieces to set on top of the side pieces, secure strips o wood 3 in. wide and as long as the form, and nail ther on the arched pieces; then secure all in place, after clean ing out all old firebrick around the door at the boile front. One end of the mould should butt against th boiler front, the bottom resting upon the dead plate.

Mix one pound of portland cement to each 10 lb. o fire clay, and have the mixture fairly stiff, but wet an properly mixed. Pack the mixture in firmly around th mould, having it at least 9 in. thick, if possible. Addin cement assists in a quick set.

The arch should stand at least one week before a slo fire is started. Do not try to remove the wooden form but allow it to burn away. If a double-door arch i required, make two boxes, leaving space for the fire cla between them. I have known of arches built in this wa to last for years. No skill is necessary in doing th job. The expansion will probably cause a few cracks t appear, but they will be no worse, and probably not s bad as those which form in firebrick arches.

Toronto, Ont., Can. JAMES E. NOBLE.

QUESTIONS BEFORE THE HOUSE

Heated Eccentric

Referring to the inquiry of H. L. R., in July 1 issue, I suppose there are eccentric straps that are not babbitted, but I have had no experience with them. If a babbitted eccentric strap runs hot enough to soften the babbitt so that it "runs" or slips, the oil grooves and holes are in danger of being covered by the slipping babbitt. This must be determined by an examination of the inside of the strap. If the babbitt has run into the grooves it should be dug out with a pointed scraper. Very often when babbitt gets that hot some of it slips onto the extreme heel of the strap and remains there, forming a rough spot on the strap heel that should be removed with a scraper before the eccentric strap is used again. So that if H. L. R. had a babbitted eccentric strap and it ran so hot as to slip the babbitt, he should do more than insert shims to remedy the trouble.

H. G. Gibson.

Washington, D. C.

Thermal Loss in Four-Valve Engines

In his article "Corliss Versus Four-Valve Engine," on page 49, July 8, issue, C. R. McGahey states that "The thermal loss is greater in the four-valve engine, as the temperature of the cylinder is changed about twice as often as with the Corliss engine." This statement seems to me to be very much open to doubt, as the surface of the cylinder is much less in the four-valve engine than in the Corliss, and the fact that the alterations in temperature take place so rapidly must operate to reduce the losses as there is no time for any part of the cylinder except the thinnest skin to participate in these changes.

A. H. Pugh.

Cincinnati, Ohio.

Strain on Stay-Bolt

In the item, "Strain on Stay-Bolt," p. 834, June 10 issue, the elasticity of the bolt and boiler plate have been neglected. While the effects of elasticity are uncertain and to be on the right side of safety it may be customary to disregard elasticity in ordinary computations, an analysis of the conditions goes to show that in a case of this kind elasticity has considerable influence on the stresses both before and after subjecting the boiler to steam pressure. If the boiler stay consisted of a helical pull spring and the boiler sheet sprung when the original 8000-lb. strain was put on the stay, then when 10,000-lb. steam pressure comes against the plate, the stay would become farther elongated, but the boiler plate would spring back toward its original position; or in fact there might be sufficient strain in the stay to elongate it so much as to permit the plate to bulge outward beyond its normal shape and thus relieve the stay of all strain due to the outward spring of the plate. In any event the strain on the stay would be the strain due to the boiler pressure plus whatever strain might be created by the elasticity of the plate after the latter assumes a change of form corresponding to the increased length of stay.

Allowing that the original strain of 8000 lb. would produce a deflection in the plate of 0.031 in., and that for the same strain a stay of 1¼ in. diameter and about 16 ft. long had been elongated 0.029 in., and calling x = the total deflection of the plate after screwing up the outside nut, then when there is a pressure within the boiler of 100 lb. per sq. in., the total pressure supported would be

$$10 \times 10 \times 100 = 10{,}000 \text{ lb.},$$

and the total strain in the body of the stay would be

$$S = 10{,}000 + \left(\frac{x}{0.031} \text{ of } 8000\right) \quad (1)$$

Considered only with reference to the original strain in the body of the stay and the increase accompanying the increase of elongation amounting to $0.031 - x$, the total strain in the body of the stay would be

$$S = 8000 + \left(\frac{0.031 - x}{0.029} \text{ of } 8000\right) \quad (2)$$

As (1) equals (2) then

$$10{,}000 + \left(\frac{x}{0.031} \times 8000\right) = 8000 + \left(\frac{0.031 - x}{0.029} \times 8000\right)$$

from which it is found that $x = 0.0123$ in.

Hence from (1) the strain in the body of the stay is found to be

$$S = 10{,}000 + \frac{0.0123 \times 8000}{0.031} = 13{,}174 \text{ lb.}$$

In the part of the stay between the inner and outer nut the length would be too short for any stretch so the stress between the nuts would be practically

$$13{,}174 + 2400 = 15{,}574 \text{ lb.}$$

If the bolt had been very short so that there would have been little or no stretch, then the stress after pressure was applied in the body of the stay-bolt would have been very nearly 18,000 lb. and 20,400 lb. between the inner and the outer nuts; and in the other extreme case as where a heavy cylinder head is bolted up on a hard, unyielding gasket with comparatively light studs, the tension in the studs will be very little more than the fluid pressure.

H. D. Fisher.

Newton Highlands, Mass.

Test of Valve and Piston Tightness

We have read with interest, in the July 22 issue, page 121, the article entitled "Test of Valve and Piston Tightness." You will perhaps be interested to learn that in 1885 at the Exposition of Anvers our Bollinckx Corliss engine ran for six months with one cylinder head removed while producing a part of its power, without leaks, although a pressure of seven atmospheres was acting on the other side of the piston.

Brussels, Belgium. H. Bollinckx.

What Becomes of the Water

T. G. Thurston's letter on the above subject in the une 17 issue is noted. I do not know what becomes the water in the sight-feed glass, but I think that he will use glycerin instead of water, his troubles will ntirely disappear and at the same time a much more gular feed of oil will be obtained. I have found it ossible to reduce the quantity of cylinder oil used, wing to the more regular feed of small drops, caused the greater difference in the specific gravities of water nd oil and glycerin and oil. Anyone who once gives ycerin a thorough trial in sight glasses of lubricators ill not readily go back to water.

E. R. Pearce.

Rochdale, England.

Orsat or CO_2 Recorder?

When a correspondent in a recent issue of Power ites that he prefers to use an Orsat apparatus rather an a recording instrument for CO_2 analysis, inas uch as an automatic CO_2 recorder leaves much be desired, I cannot help thinking that this must be personal view and not one generally taken by engineers rsed in this interesting branch of engineering. On e other hand I should very much like to know which pe of instrument he has had in use.

I have been using CO_2 recorders for about two years, nd have rarely experienced any trouble with them. henever I have checked them up with the Orsat the sults almost perfectly coincided.

Our instrument employs a large steel tank for absorbg the CO_2. Gas bubbles through the liquid, which is ustic potash of a specific gravity of 1.27. Besides bsorption through bubbling there is a large surface th which the gases come in intimate contact. We use lb. of caustic potash every month, which costs about c. The instrument is used day and night and makes out 20 analyses per hour. This charge lasts a full onth, and we have found by means of frequent Orsat sts that after four weeks the record is just as correct at the time the tank was filled.

There does not appear to be any defect in this part the instrument, and then there is no continuous flow gas through the caustic potash. If this were the case, few days would be sufficient to thoroughly exhaust the lution, even a few hours as the correspondent states. The as should pass through the instrument and the caustic otash at intervals, that is, only when the instrument anyzes. To get a correct analysis with the recorder, ree minutes should be given, i.e., the speed of the corder should not exceed 20 analyses per hour.

For several reasons, the Orsat is, no doubt, very useful, it permits a complete analysis of the gases and should, herefore, be in every uptodate plant, whether a CO_2 reorder is used or not.

If 10 to 12 per cent. of CO_2 is maintained in the exit ases of any good furnace and no heavy smoke is being ade, the engineer may be quite satisfied that he is aking little if any CO, and therefore it is not necessary frequently test the gases for CO and O. A CO nalysis taken every now and then is of help to the engieer, but I do not think that it would pay the average boiler plant to install carbon-monoxide recorders, which are now on the market.

For producer gas a CO recorder would be of the greatest advantage. This instrument stands in exactly the same relationship to a producer plant as a CO_2 recorder to a boiler plant. In both cases the percentage of gas analyzed is to be kept as high as possible.

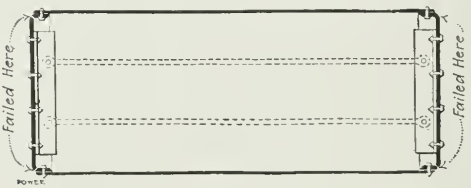
The correspondent mentioned the initial expense of a CO_2 recorder. We burned 20 tons of coal per 24 hours before the CO_2 recorder came to the plant, and we thought that we were doing good work. We have since decreased the coal consumption to 16 tons per 24 hours. During the four weeks which we had the instrument on trial the percentage of CO_2 was raised from 6 to 13 per cent., average, thus reducing the coal bill 10 per cent., which means a saving of about $10 per day. The instrument has paid for itself in less than five weeks, and consequently all are enthusiastic about it. We keep it in perfect working order and give it the attention which it no doubt deserves. We have realized its value as a fuel saver and as a general check over men and conditions.

F. D. Harger.

New York City.

Why Did Hot-Water Tank Fail?

Answering the injury by R. Cederblom, page 139 of the July 22 issue, the tank failure was due to a concentration of the distortion caused by the pulsations and pressure in the tank at the points indicated by the arrows in Mr. Cederblom's drawing of the tank in question. The effect or action of these pulsations and pressure at the points indicated by the arrows is practically the same as would result if we took a bolt of a length equal to that



Construction of Tank That Failed

of the radius of the tank, and fastened one end of it firmly in a vise and continuously moved the opposite end back and forth through an arc equal to the movement of the center to the head of the tank in a longitudinal direction. All of the bending stresses would be concentrated close up to the jaws of the vise, and the bolt in time would break off at this point.

The deterioration in the case of the tank at the points of concentration of the stresses, due to pressure and pulsations is, however, hastened considerably by the action of the water in the tank. At these points, the hinge action, as we will call it, which allows of the movement of the head (and which made the angle irons necessary) produces little cracks. Water gets in these and promotes corrosion and pitting.

The tank very likely showed signs of distress long before the angle irons were installed, which was too late to remedy what had been done. In my judgment the angle irons were too short.

Fort Madison, Iowa. Thomas C. Robinson.

INQUIRIES OF GENERAL INTEREST

Coke Heat Value—What is the calorific value of coke as compared with bituminous coal?

W. N. A.

It varies from 12,000 to 13,000 B.t.u. per lb., according to the coal from which it is derived and the method of coking the coal. A pound of average coke from Pocahontas coal has about 87 per cent. of the calorific value of a pound of Pocahontas bituminous coal.

Required Vacuum—Why does a steam turbine require a higher vacuum than a reciprocating engine?

F. E. K.

A steam turbine works more economically the higher the vacuum, but when a reciprocating engine works condensing the cooling effect on the cylinder walls of a vacuum greater than about 26 in. generally counteracts the advantages of the higher vacuum for reducing the back pressure.

Case-Hardening Pins—I am soon to put in new pins in the valve gear of our Corliss engines. How will I case-harden the pins?

J. C. J.

Melt about 2½ lb. of cyanide of potassium in a ladle. After the pins have been finished to a smooth surface heat them, one at a time, to a dull cherry red, and plunge them into the liquid cyanide. Each pin should remain in the liquid about one minute and then be plunged in clean water. The longer the pins remain in the cyanide the thicker the hardened wall of metal will be.

Try-Cock Blows Dry Steam—The water column of a high-pressure boiler has just been blown down showing no obstructions. When closed the glass fills, yet when a try-cock is opened only dry steam issues. What is the explanation?

J. S.

The water having just been changed in the column is at practically boiler temperature, which in a high-pressure boiler is considerably above the evaporation temperature at atmospheric pressure. Consequently, when the try-cock is opened, the pressure on the issuing water being suddenly released, it flashes into steam.

Changing Governors—If one had a slide-valve engine with a throttling governor and wished to use a shaft governor, what changes would have to be made to the valve?

F. E. K.

Unless the engine is already provided with some form of balanced slide valve capable of being moved with less friction than the ordinary slide valve, the valve would have to be changed to a balanced valve. In making such change the valve chest would probably have to be altered to accommodate the new type of valve. A shaft governor may be powerful enough to operate an ordinary slide valve, but such a combination is rarely satisfactory. The valve would need both inside and outside lap.

Chimney Capacity—What capacity has an iron stack 5 ft. in diameter and 135 ft. high? This one needs repairing. Will it do any harm to shorten it by removing the damaged section?

R. A. H.

The ordinary natural-draft capacity of this stack is 650 boiler-horsepower. Any shortening of the stack will lessen the draft in the boiler furnaces. The drafts due to different heights of stack are as the square roots of the heights. For instance, reducing the height to 121 ft., since the square root of 135 is 11.62 and the square root of 121 is 11, would reduce the capacity to

$$650 \times \frac{11}{11.62} = 615.3 \text{ hp.}$$

Constructing Blowoff Tank—What is the best material for a blowoff tank? Would it be safe to drain one into a 12-in. common tile drain having about 6 ft. fall in 1200 ft., leading to a creek? What is the best form for a blowoff tank?

S. F. G.

A blowoff tank being mainly for receiving blowoff water, and permitting it to cool off before being discharged into a sewer, should be large enough to hold about one-eighth the water of a boiler. It should be wrought iron or steel plate and strong enough to safely hold the greatest pressure carried by the boiler. In addition to an inlet for receiving the blowoff and an outlet for discharging it, it should have a vapor pipe carried up through the roof (always left open), a safety valve and a manhole for cleaning. Blowoff water should not be discharged into an earthen sewer pipe until it has cooled down to about 100 deg. F. as expansion from heat would soon cause the sewer to break up. (The fall of 6 ft. in 1200 would be sufficient for proper drainage if the pipe is carefully laid, i.e., with a uniform grade and with good even joints. The best form for a blowoff tank is cylindrical with standard bumped heads made of boiler plate.

Accelerating Time of Free Discharge—How is the interval of time computed within which a gas or liquid reaches its theoretical velocity of flow from an orifice under pressure, assuming the valve to open instantly?

M. W. C.

The time would be the same as that required for a body to fall in vacuo from the height of a column of gas required to produce the head or pressure under which discharge takes place. Knowing the weight of the gas or liquid per cubic foot the head in feet required to create a given pressure per square inch would be

$$h = \frac{\text{Pressure per sq.in.} \times 144}{\text{Wt. per cu.ft.}}$$

and, as the formula for falling bodies in which t = the time in seconds, is

$$t = \sqrt{\frac{2h}{g}}$$

then, as

$$g = 32.16,$$

the time in seconds to acquire the velocity due to the head would be:

$$t = \sqrt{\frac{2 \text{ (pressure per sq.in.} \times 144)}{32\ 16}}$$

Required Cylinder Diameter—What diameter of cylinder will be required to develop 50 hp. in an engine having a stroke of 4 ft., making 45 r.p.m. when working with a mean effective pressure of 30 lb.?

S. E.

Substituting the given values in the formula,

$$Hp = \frac{P\,L\,A\,N}{33{,}000}$$

where

P = Mean effective pressure in pounds per square inch;
L = Length of stroke in feet;
A = Area of piston in square inches;
N = Number of strokes per minute = twice the number of revolutions per minute;

then

$$50 = \frac{30 \times 4 \times A \times 90}{33{,}000}$$

or

$$A = \frac{50 \times 33{,}000}{30 \times 4 \times 90} = 152.77 \text{ sq.in.}$$

Since the area is equal to the square of the diameter multiplied by one-fourth of $\pi = 3.1416$ or

$$\frac{\pi}{4} = 0.7854$$

the diameter of the piston should be

$$\sqrt{\frac{152\ 77}{0\ 7854}} = 13\ 9 \text{ in.}$$

or practically 14 in.

Engine Alignment—How can it be determined whether or not the cylinder and guides are in line?

G. A. M.

After loosening the gland of the piston stuffing-box turn the engine over slowly. If the cylinder is not in line with the guides the gland will be moved to one side, or up or down.

ENGINEERS' STUDY COURSE

Evaporation—II

Steam Tables

In the first article it was shown that the boiling temperature of water is different for different pressures. Thus, at atmospheric pressure (14.7 lb. per sq.in. absolute, or zero gage) the boiling temperature is 212 deg. F., while at 150-lb. gage it is 365.9 deg. The higher the pressure, the higher the boiling temperature.

In addition, the latent heat, or the quantity of heat required to convert a pound of the water from its liquid to vaporous form, varies quite extensively with variation in pressure. Thus, the latent heat of steam at atmospheric pressure is 970.4 B.t.u. per pound, while at 150-lb. gage it is only 856.9 B.t.u., or more than 100 B.t.u. less per pound. The higher the pressure, the lower the latent heat.

The volume of a pound of steam varies greatly with variation in pressure. At atmospheric pressure 1 lb. of steam has a volume of 26.79 cu.ft., while at 150-lb. gage the volume is only 2.758 cu. ft., or only about one-tenth as much. The higher the pressure the smaller the volume per unit of weight. It is this characteristic of the steam that makes it suitable for use in engines, turbines, etc. The steam is generated at a high pressure with a small volume per unit of weight, then let into the cylinder or turbine stage where its pressure forces the piston ahead—provided the resistance of the piston is not greater than the pressure of the steam, which is the case when the engine is on dead center or when it is too heavily loaded.

As the pressure of the steam forces the piston forward, more room is created in the cylinder and the pressure is slightly relieved or lowered. As the pressure lowers, the steam must expand to fill the increased space because for every pressure there is a corresponding volume just the same as for every pressure there is a corresponding boiling temperature, latent heat, etc. And the relation of these quantities to each other never varies so long as steam is steam. They must fulfill Nature's laws, which are immutable—cannot be repealed or changed.

However, this action of steam in the cylinder of an engine is a little off the subject now occupying our attention, and a more thorough study of it will be offered in its proper turn later on.

Because the boiling temperature, latent heat, etc., are different for each different pressure, we have what are called the steam tables, or, to be more exact, tables of the properties of saturated steam. These are exceedingly convenient for finding the other factors when any one is known, and it behooves all who intend to continue on in power-plant study and work to become familiar with the tables.

A modified and condensed form of the latest accepted steam tables is presented herewith. The original tables were compiled by Professors Lionel S. Marks and Harvey N. Davis, and published by Longmans, Green & Co., through whose courtesy we are permitted to publish Table 1, herewith.

Gage and Absolute Pressure

In the first column of the table are given the vacuum and gage pressures; in the second, absolute pressures. In the first paragraph of this article you may have noticed that atmospheric pressure was given as 14.7 lb. per sq.in., absolute, or zero gage. This was done because in these modern days there are, unfortunately, two standards of pressure measurement. Gage pressure takes its name from the instrument commonly used for measuring boiler steam pressure. Now, the ordinary pressure gage used on a boiler does not indicate the total pressure actually existing inside the boiler. It only measures the difference between the pressure of the steam within the boiler and the pressure of the atmosphere without.

This is due to the construction of the gage, which consists principally of a curved hollow metal tube open at one end. The hollow interior of the tube connects at the open end with the interior of the boiler while the exterior of the tube is exposed to the pressure of the atmosphere. When the pressure acting on the inside of the tube is equal to the atmospheric pressure acting on the outside, the tube is in its normal position and the pointer on the dial of the gage, connected to the tube at the closed end, indicates zero on the scale. When the pressure within exceeds the atmospheric pressure without, the tube tends to lose its curve and straighten out. And as the closed end, to which the pointer is attached, is the only end free to move, the change in the position of the tube is all transmitted, through suitable mechanism, to the pointer. This swings away from the zero mark and points to the position on the scale corresponding with the pressure existing in the boiler over and above that of the atmosphere outside.

Absolute pressure means the total pressure actually existing in the space where the measurement is taken whether this be in a boiler, a condenser, in the open atmosphere or anywhere else. It does not take into account any outside pressure that may happen to be acting on the measuring gage or instrument. Hence, the zero point on the absolute-pressure scale is at absolute vacuum. If a whole boiler, pressure gage and all, were inclosed in a vacuum, the gage would then show absolute pressures because, there being absolutely no pressure outside, the difference between the inside and outside pressures would equal the total pressure actually existing inside the boiler.

The absolute-pressure system of measurement is the more accurate one because it is not dependent upon the more or less variable pressure of the atmosphere. An absolute-pressure gage is more complicated and expensive, however, than the ordinary gage used in boiler work, and, hence, far less popular. So, in actual steam-plant operation gage pressures are the ones mainly encountered. But gage pressures can easily be translated into absolute

essures by adding the amount of atmospheric pressure isting at the location of the plant under consideration. hus, at sea level, absolute pressure may be taken as ge pressure plus 14.7 lb. per square inch. At a higher titude than sea level, the atmospheric pressure is less; nce, care must be used, in cases where the difference appreciable, that the proper value be employed. For stance, at Denver the average atmospheric pressure is it 12.5 lb. per square inch. Consequently, the first lumn of Table 1 would be over 2 lb. out of the way id should not be used for accurate work. The thing do in such cases is to translate into absolute pressures

TABLE I PROPERTIES OF SATURATED STEAM

From Marks & Davis' Tables. Courtesy of Longmans, Green & Co.

1	2	3	4	5	6	7	8
			Total Heat Above 32° F.				
cuum in. of ercury	Absolute Pressure, Lb. per Sq.In.	Temperature, Degrees Fahrenheit	Heat of the Liquid h B.t.u.	In the Steam H B.t.u.	Latent Heat $L = H - h$ B.t.u.	Volume of Steam Cu Ft in 1 Lb.	Weight of 1 Cu.Ft. of Steam Lb.
7.88	1	101 83	69 8	1104 4	1034 6	333 0	0.00300
5.85	2	126 15	94 0	1115 0	1021 0	173 5	0.00576
3.81	3	141 52	109 1	1121 6	1012 3	118 5	0.00845
1.78	4	153 01	120 9	1126 5	1005 7	90 5	0.01107
0.74	5	162 28	130 1	1130 5	1000 3	73 33	0.01364
7.70	6	170 06	137 9	1133 7	995 8	61 89	0.01616
5.67	7	176 85	144 7	1136 5	991 8	53 56	0.01867
3.63	8	182 86	150 8	1139 0	988 2	47 27	0.02115
1.60	9	188 27	156 2	1141 1	985 0	42 36	0.02361
9.56	10	193 22	161 1	1143 1	982 0	38 38	0.02606
7.52	11	197 75	165 7	1144 9	979 2	35 10	0.02849
5.49	12	201 96	169 9	1146 5	976 6	32 36	0 03090
3.45	13	205 87	173 8	1148 0	974 2	30.03	0 03330
1.42	14	209.55	177.5	1149.4	971 9	28.02	0 03569
Lb. age ress.							
0	14 7	212 0	180 0	1150 4	970 4	26 79	0 03732
5.3	20	228 0	196 1	1156 2	960 0	20.08	0 04980
10.3	25	240 1	208 4	1160 4	952 0	16.30	0 0614
15.3	30	250 3	218 8	1163 9	945 1	13 74	0.0728
20.3	35	259 3	227 9	1166 8	938 9	11 89	0.0841
25.3	40	267 3	236 1	1169 4	933.3	10.49	0 0953
30.3	45	274.5	243 4	1171 6	928.2	9.39	0 1065
35.3	50	281 0	250.1	1173.6	923.5	8.51	0 1175
40.3	55	287 1	256.3	1175 4	919.0	7.78	0 1285
45.3	60	292.7	262 1	1177 0	914 9	7.17	0.1394
50.3	65	298 0	267 5	1178.5	911 0	6.65	0.1503
55.3	70	302 9	272.6	1179.8	907.2	6 20	0 1612
60.3	75	307 6	277.4	1181 1	903.7	5 81	0.1721
65.3	80	312.0	282.0	1182.3	900.3	5.47	0.1829
70.3	85	316 3	286.3	1183 4	897 1	5.16	0 1937
75.3	90	320 3	290.5	1184.4	893 9	4 89	0 2044
80.3	95	324 1	294 5	1185.4	890 9	4 65	0.2151
85.3	100	327 8	298.3	1186.3	888.0	4 429	0.2258
90.3	105	331 4	302 0	1187.2	885.2	4.230	0.2365
95.3	110	334 8	305 5	1188.0	882 5	4.047	0.2472
00.3	115	338 1	309.0	1188 8	879.8	3 880	0.2577
05.3	120	341 3	312.3	1189 6	877 2	3 726	0.2683
10.3	125	344 4	315.5	1190 3	874 7	3 583	0.2791
15.3	130	347 4	318.6	1191.0	872.3	3 452	0.2897
20.3	135	350.3	321.7	1191 6	869 9	3.331	0.3002
25.3	140	353 1	324 6	1192 2	867 6	3.219	0.3107
30.3	145	355.8	327.4	1192 8	865 4	3.112	0 3213
35.3	150	358.5	330.2	1193.4	863 2	3 012	0.3320
40.3	155	361 0	332 9	1194 0	861.0	2 920	0 3425
45.3	160	363 6	335.6	1194.5	858.8	2 834	0.3529
50.3	165	366 0	338.2	1195 0	856.8	2.753	0.3633
55.3	170	368.5	340.7	1195.4	854.7	2 675	0.3738
60.3	175	370 8	343.2	1195.9	852.7	2.602	0.3843
65.3	180	373 1	345.6	1196.4	850.8	2.533	0.3948
75.3	190	377.6	350.4	1197.3	846.9	2.406	0.4157
85.3	200	381 9	354.9	1198.1	843.2	2.290	0.437
95.3	210	386.0	359 2	1198 8	839.6	2.187	0.457
00.3	215	388 0	361.4	1199 2	837.9	2.138	0.468

id use the second column. For most ordinary purposes, however, the errors caused are hardly important ough to warrant any large amount of extra work.

The third column of Table 1 gives the temperature the steam at various pressures. This temperature is so the boiling temperature of water under the correponding pressure, as was carefully explained last week.

Heat of the Liquid

In the fourth column is given the heat of the liquid, r, as it is sometimes called, the heat in the water. The gures in this column represent the number of B.t.u. equired to raise the temperature of 1 lb. of water from 2 deg. to the boiling temperature at the pressure given. Thus, at atmospheric pressure or zero, gage, the heat of the liquid is 180 B.t.u. This can be easily checked from the knowledge gained from previous lessons. It was learned by definition that it takes 1 B.t.u. to raise the temperature of 1 lb. of water 1 deg. Then, as there are 212 — 32 = 180 deg. difference between 32 and the boiling point, it must require 180 × 1 = 180 B.t.u. to raise 1 lb. of water from 32 deg. to the boiling temperature at atmospheric pressure.

As the pressure grows higher, the heat of the liquid does not exactly correspond with the number of degrees difference between 32 and the boiling point. Thus, at 35.3-lb. gage, or 50-lb., absolute, pressure, the number of B.t.u. required to raise the temperature of 1 lb. of water from 32 deg. to the boiling point (the heat of the liquid) is 1.1 greater than the number of degrees between those two points. This is because the heat required to raise the temperature of 1 lb. of water 1 deg. increases gradually as the pressure increases above 14.7 lb. per square inch.

In the sixth column of Table 1 are given the values of latent heat of steam at the various pressures.

Total Heat in Steam

The figures in column 5 are the sums of the figures in columns 4 and 6 and they show the total heat contained in 1 lb. of steam above the temperature of 32 deg.

It may be a source of wonder to some why columns 4 and 5 are headed "Total Heat Above 32 Deg., F." The explanation is this:

Every substance, no matter what its temperature, contains some heat. We think of a piece of ice as a pretty cold chunk of solid water and would hardly suspect, on first thought, that it could have any heat concealed about it. Yet, a pound of ice just at the freezing point (32 deg.) possesses 16 B.t.u. more than a pound at zero temperature. Ice may possess different temperatures just the same as water, steel or steam. Then, ice at zero is certainly colder than ice at 32 deg. and, *vice versa*, ice at 32 deg. must be warmer than ice at zero, and hence it must possess more heat.

In fact, no matter how cold you may make a substance, it still must possess some heat. Suppose, you refrigerated a piece of ice until its temperature went down to —75 deg., in all 107 deg. below the normal freezing point of water. That would be pretty cold, wouldn't it? Yet that ice could be refrigerated still more, say, to —100 deg., showing that even at —75 deg. it hadn't yet lost all the heat it possessed.

Man has not yet discovered just what the absolutely lowest temperature is. He has succeeded in obtaining artificially some very low degrees, but he has never reached the lowest limit because his apparatus fails first.

Then, in view of the fact that we do not know at just what temperature the point of complete lack of heat exists, we must establish a "base" line to work from when we talk of or deal with quantities involving "total" heat. In dealing with steam, this base line is the freezing point of water under atmospheric pressure, or 32 deg. F. Thus, the total heat of the liquid or in the water is the heat that must be imparted to 1 lb. of water in order to raise its temperature from 32 deg. to the boiling point. And the total heat in the steam is this quantity plus the latent heat.

Column 7 gives the volume of 1 lb. of steam in cubic feet and column 8 the weight of 1 cu.ft. in pounds.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

The surest thing you know is that if you go to the Springfield convention next week, you'll have the time of your young life. Are you going?

⁂

"We must trust each other or the world will go wrong," says "Leslie's Weekly." This is a very pretty sentiment, but great Cæsar's spook! not everybody's doing it. Right now, who is trusting you or me? I trust you're well; you may trust I'll croak, which is a sentiment after a kind. To prove the trust you have in me, will you slip me five bucks? And you say, "The world has indeed gone wrong!" That's what I mean, exactly.

⁂

"Once a stoker, he died worth millions."—Headline.

Why make all this daily-press noise about it? It's a fine thing to have risen (or fallen, if you prefer it) from a stoker to a millionaire, but do you know any stoker today who would change places with the dead millionaire? Not on your favorite scoop, you wouldn't!

⁂

Pythias had his Damon, but Pyth didn't have anything on Springfield, which has Walter Damon. Walt came to Springfield 22 years ago and started in as a wheelbarrow engineer in the boiler room of the same plant in which he is today its chief engineer; and it's the largest plant in that city. He's also chairman of the local convention committee. This means he'll give you the city and everything in it before he'll let you go home dissatisfied. Another good reason for going to the convention.

⁂

"Since Adam's time there have been changes," says "Printer's Ink." It takes some wise little guy to discover such a deep-hidden fact. Adam is a sore topic with us; we blame him for having wished on us a long life of toil and travail we have never as yet got accustomed to.

⁂

This modern Babylon, New York City, will have a real coroner if International President Timothy Healy (elected eight times) of the Eccentric Firemen is elected on the city ticket this fall. If Tim sits on the corpse, it'll get full justice. Tim is a live one, and we pity the divil who killed the "corp!" He's dead already, meaning the malefactor as well as the corp. The only thing Tim ever ran from is his friends; offices, and his enemies, he runs for, and gets them. As a coroner, he looks like a dead winner!

⁂

Civil Engineer or Dentist?—"Engineering News."

Our contemporary reprints a letter advising a young man to learn dentistry rather than civil engineering; it says the emoluments are greater. To our mind, it takes a big pull to get anywhere with either of these professions. Personally, we, too, favor the dentistry; it's more filling; it's a drawing business; you get in with the upper set by gum! and it's painless—to the dentist. Your clients look at you with open mouth at your ability. It's a nerve-killing business, but it pays.

⁂

"Have you ever realized the value of expressed appreciation as an aid in the successful handling of your employees?" asks "Coal Age." As an employer, we have had but small concern. As an employee, we've several times capered on our hind legs, because the Old Man expressed his appreciation of our well doing. It's good dope; it tickles us all, and it costs our bosses nothing, unless they have an over-rated sense of their own importance and aloofness.

⁂

Engine running on buttermilk? Yep, at the recent Gas Power Show in Kansas City, an exhibitor displayed a sign reading: "See the ——— Engine Running on Buttermilk." A small gasoline engine, running at full speed, was supported on four bottles of buttermilk. One of our well-wishers made us the goat on this tale. We hope it's true.

⁂

The musical-instrument trade has not been affected by the war in Southeastern Europe, says a consular report. That's just it; some of these instruments stimulate a war. There can't be peace in the hearing of a wheezy concertina or a squawking fiddle; either would start a dog or cat fight.

Lunkenheimer Monitor Automatic Water Gage

This water-gage is made in two patterns, intended for 200- and 300-lb. working pressures, respectively. They are made either right or left hand, as desired, to facilitate operation.

Should the gage-glass break, ball check valves automatically seat themselves, owing to the rush of steam and water on one side and the lack of pressure on the other. They prevent the escape of steam and water and permit the safe closing of the hand-operated valves before renewing the glass.

To renew the glass, it is only necessary to loosen the stuffing-boxes, take off the cap and substitute a new glass after which the stuffing-boxes are tightened and the cap replaced.

Particular care has been exercised in the design of the gage to facilitate cleaning, and access can be readily had to any part by the removal of plugs. By removing the bottom plug and opening the regrinding valves to their greatest extent, a rod can be inserted through the body and tail pieces, and any sediment that might have collected in or around the entrance of the tailpieces can be removed. By unscrewing other plugs the check balls will fall from the body, as they rest on inclined surfaces.

It has been the practice to attach both valve pulleys together by means of a chain or cord pinned to the pulleys, so that the proper closing of one depended entirely on the closing of the other. While in some cases this method was satisfactory, unless great care was exercised in pinning the chain to the pulleys, or after the valves had been reground several times, one of the valves would not seat properly. To overcome this difficulty the Lunkenheimer Co., Cincinnati, Ohio, have arranged it so that both valves can be made to seat independently of each other. This arrangement consists of a block pulley operating over a chain, which is pinned to both the upper and lower pulleys. Should one of the valves become closed before the other, a continued pull on the block chain will close it.

The valves are constructed to be reground when worn. The valve-seat opening is large and a free and unobstructed passage for the water and steam is insured.

The gage cannot show a false level, with free pipe connections, as the ball checks are so constructed that unless the glass breaks, they will, owing to their weight and position, fall away from their seats.

⁂

Endura Sheet Packing

A new sheet packing, known as Endura, is made of a vegetable fibre and so treated that it resists the softening and rotting effects of oil and water (hot or cold) acids, benzine or gasoline, coal-tar, brine, ammonia, etc., and increases its toughness and tensile strength, without adding greatly to the weight of the fibre sheet. It is not recommended for steam or dry-heat conditions, but for use under moist conditions. It is also suitable for pump packing where the water contains acids and is said to give excellent results with water containing 4 per cent sulphuric acid.

This packing is manufactured by the Endura Manufacturing Co., 6301 Eastwick Ave., Philadelphia, Penn

Cleaning and Inspecting Water-Tube Boilers

By F. T. Ravlin

When about to clean a boiler it should be cut off from the steam header, allowed to cool, given proper air vent and the blowoff valve opened to drain out all water. The manhole plates in the steam and mud drums and the hand-hole plates should be removed and the blowoff valves closed after washing out.

A hose should be used with 100 lb. water pressure, if possible, to wash out the drums thoroughly, and all remaining scale should be removed with scrapers. The inside feed-water pipe should be removed, thoroughly cleaned and replaced and the water-column connections and gage cocks inspected. After removing the bottom water-glass bonnet, the connection to the boiler should be rodded out. With all caps on the upper ends of the tubes removed, an air- or steam-driven rotary cleaner under not less than 75 lb. pressure, should be applied to each tube for not less than three or four minutes, and more when the scale is thick.

The cleaner should be fed in at a uniform speed and not allowed to remain in one place while in operation, as the tube is likely to be injured by the cutter. A stream of water should be run into the tube to wash out the scale ahead of the cutter. After boring the tubes by placing a light at the front end of each, they may be carefully inspected from the rear end.

When the boiler is not badly scaled only the lower row of caps and a row running diagonally across the headers from each corner on the rear end, need be opened for inspection, thus saving time in cleaning. The caps and bolts should be cleaned thoroughly and all inside tube plates thoroughly inspected, and if sprung or cracked around the bolt holes, replaced with new ones. Ground-joint caps should be refitted by rubbing the cap with a circular motion, on the header seat, using a suitable grinding compound. Care should be exercised in replacing each tube plate to see that it fits onto its seat correctly. A mixture of black lead and engine oil should be used on the cap-bolt threads.

Under no consideration must a wrench over 24 in. long be used to tighten up the cap nuts. No leak should be allowed, as the steel will cut out in a short time.

Gaskets should be used on manhole and mud-drum plates, care being taken to thoroughly coat them with oil and black lead on the outer face after they have been fitted carefully on the plates. The plates should be inserted in the drums and lined up properly with the openings, the crabs put on and the bolts drawn up tight.

After filling the boiler with hot water and testing with the pressure carried on the feed-water line, all joints should be examined for leaks. If defects are found, the boiler should be blown down to the desired level and the defects remedied.

Next the baffles should be examined and repaired and the tubes swept and thoroughly inspected, especially over the fire. If any of the tubes are found with knuckles or cracks they should be replaced with new ones. Then the bridge-wall and combustion chamber should be cleaned, and the furnace walls and grates examined, as well as the drum plates, inside and out, to see that all rivets are tight, and that no pitting or corrosion has occurred on any part of the shell.

Mud-drum nipples are apt to rapidly deteriorate and should receive close attention and be tested with a small hammer. When the boiler is under steam it should be seen that the safety valve releases at the proper pressure. After the boiler is ready and put into service it should be blown down to one gage of water, the damper opened slightly and the fire started. It is advisable to clean the outside of the headers and mud-drum nipples on both sides, and paint them with red mineral paint each time the boiler is washed out.

Proposed Smoke Rules for Cincinnati

The report of the Boiler, Furnace and Stack Code Commission appointed by the Mayor of Cincinnati early this year was recently handed in, and it is expected that the Council will pass the recommendations, making them a part of the present smoke ordinance.

Among the recommendations are the following important items:

The Smoke Inspection Department shall supervise the construction of steam-boiler furnaces, and require alterations of furnaces where necessary.

All plans and specifications for boilers and furnaces except such as are for installation in private residences or in apartments having less than five families, shall be submitted to the Smoke Inspection Department, and a permit received from that department before work of installation is begun.

No furnace shall be finally put into operation until the Chief Smoke Inspector has issued a certificate of approval.

The Chief Inspector shall have no authority to prescribe to any consumer, or to recommend any particular brand of fuel or fuel from any particular mine, but he may advise as to the particular properties of the fuel best adapted to any particular installation.

The permissible density of smoke shall not be darker than Scale No. 1, which scale has for a basis four thicknesses of gray glass, one thickness of which will cut off 60 per cent. of the light from a flame having the power of 16 candles.

Each boiler with more than 1500 sq.ft. of heating surface, using coal as fuel shall be provided with an automatic mechanical stoker.

All hand-fired furnaces on boilers carrying more than 20 lb. steam pressure shall be provided with steam-air jets, there being one jet for each 250 sq.ft. of heating surface but not less than three jets to any one furnace.

The minimum distance between the grate and tubes of hand-fired horizontal water-tube boilers shall not be less than 36 in. Boilers of this type and of the vertical type when they are hand-fired must have an extension furnace. No stack for a stationary boiler shall be less than 90 ft. and 10 ft. shall be added for every right-angle bend in the breeching. Higher stacks than given by this rule are recommended.

Stacks of boilers used in the repair of old buildings or in the construction of new ones must extend to the top-most story under construction.

For more details concerning the construction of furnaces and location of stokers, write the Smoke Inspection Department. This department would undoubtedly gladly supply such information to boiler and stoker manufacturers.

Editorial comment on these proposed rules is made on page 339 of this issue.

N. A. S. E. Springfield Program

The program for the thirty-first national convention of the National Association of Stationary Engineers, to be held in Springfield, Mass., on Sept. 8 to 13, is as follows:

MONDAY, SEPT. 8

9:00 a.m. to 9:00 p.m.—Reception of delegates and visitors at the trains throughout the day; escorted by the band. Registration and distribution of badges at the Auditorium.

8:00 p.m.—Informal reception by the national officers in the Auditorium's Mahogany Room.

9:00 p.m.—Mechanical Exhibition, in Exhibition Hall. Opened by National President John McGrath and Vice-President James R. Coe.

TUESDAY, SEPT. 9

10:30 a.m.—Opening exercises of convention in Court Sq. Theater. Called to order by W. H. Damon, chairman of the Local Committee.

Convention Proceedings

Invocation—The Rev. B. D. Hahn, pastor of the State Baptist Church.

Address of Welcome—Mayor John F. Denison.

Response—National President John F. McGrath.

Address—Charles T. Bosworth, the Springfield Board of Trade.

Response—Vice-President James R. Coe.

Address—Stewart Anderson, president the Publicity Club.

Response—Past National President E. H. Kearney.

10:30 a.m.—Convention opened by National President John F. McGrath.

Appointment of Convention Committee.

Report of Credentials Committee.

Official photograph immediately after adjournment. Recess.

2:00 p.m.—Session in Grand Army Hall. Reports of national officers, license committee, educational committee, committee on history. Annual meeting of life and accident department following adjournment of session.

2:00 p.m.—Opening exercises of Ladies' Auxiliary. Called to order by Mrs. Carrie Bremmer.

Address of Welcome—Mayor Denison. Response—Past President Mrs. Louise Mullen.

3:30 p.m.—Tea and musicale in Mahogany Room. Ladies attending the convention are invited.

8:30 p.m.—Band concert in the Auditorium.

10 p.m.—Smoker and entertainment at Hibernian Hall.

WEDNESDAY, SEPT. 10.

9:30 a.m.—Regular session. Visit to Chapman Valve Co.

1:00 p.m.—Boats and trolley car pleasure trip leave for Riverside Park. Includes a clambake; athletic sports; annual ball game of Engineers and Supply Men. Prizes donated by the Exhibitors' Association. Concert and dancing afternoon and evening. Fireworks at Park in evening.

THURSDAY, SEPT. 11

9:30 a.m.—Business at this session: Reports of committees; discussion of welfare work, license legislation, state associations; convention work; methods of propagation; educational features; entertainment programs.

10:00 a.m.—Regular session, Ladies' Auxiliary.

11:00 a.m.—Annual memorial service.

2:00 p.m.—Report of board of trustees of "National Engineer." Lecture and discussion of welfare work.

2:30 p.m.—Ladies Day at Exhibition Hall. Souvenirs given this afternoon only.

8:00 p.m.—Entertainment at Auditorium by Exhibitors Association.

FRIDAY, SEPT. 12

9:30 a.m.—Regular session. Committee reports and unfinished business. Selection of 1914 convention city. Election of officers.

1:00 p.m.—Trolley trip to Mount Tom for the ladies.

8:30 p.m.—Installation of officers and presentations, at Hotel Kimball.

9:00 p.m.—Grand ball at Hotel Kimball.

SATURDAY, SEPT. 13

Delegates and visitors will be taken to the points of interest around Springfield

NEW PUBLICATIONS

PRACTICAL GEOMETRY AND GRAPHICS. By Bates and Charlesworth. Published by D. Van Nostrand Co., New York. Cloth; 616 pages, 5x7½ in.; illustrated and indexed. Price, $2 net.

The authors have written this work with the object of giving a volume to engineers, architects, draftsmen, etc., that they could use in their work and to meet the demands of students in technical schools.

There are three sections to the book: (1) Plane Geometry; (2) Graphics; (3) Descriptive Geometry. In many respects the book is similar to the many books on this subject which are available in the market, except that the chapter on loci and loci methods of solving problems and the chapters on conics, graphics and vectors are more extensive than is found in most books. Numerous diagrams are given to assist the student in grasping a knowledge of the subjects in hand.

PRACTICAL MATHEMATICS FOR TECHNICAL STUDENTS. By Bates and Charlesworth. Published by D. Van Nostrand Co., New York. Cloth; 513 pages, 5x7½ in.; illustrations; tables and indexed. Price, $1.50 net.

This book was written for those who do not combine instruction in practical mathematics with practical geometry, and who have been unable to adopt the authors' existing textbooks, "Practical Mathematics and Geometry," published in 1910.

No previous knowledge of mathematics is assumed and the work is intended to cover a two or three years' course. Although the treatment of the various branches of mathematics is rather brief on account of the size of the book, the needs of the student who must work unaided by a teacher have been considered. The book begins with simple examples in the lower mathematics and treats all the numerous branches, including exercises in the use of squared paper, and ends with chapters on trigonometry and calculus. The practical man who is normally intelligent and who must teach himself the branches of mathematics needed in his work ought to make reasonably good progress with this book providing he is persistent.

BOOKS RECEIVED

ELECTRICITY FOR THE FARM AND HOME. By Frank Koester. Sturgis & Walton Co., 7½x5¼ in. Cloth. 279 pages; illustrated. Price, $1. net.

THE SCIENCE OF BURNING LIQUID FUEL. By William Newton Best. 9¼x6¼. Cloth; illustrated; 159 pages. Price, $2.

FACTORY LIGHTING. By Clarence E. Clewell. McGraw-Hill Book Co. 9½x6½ in. Cloth; 161 pages; illustrated. Price, $2. net.

SOCIETY NOTES

The second annual outing and dinner of the Newark, N. J., Engineers Blue Club was held at Olympic Park, Newark, on Sunday, Aug. 24. The dinner was pronounced the best that had ever been given by the engineers in the East. The "Bunch" and the Engineers played a tie game of ball, the score being 5 to 5.

The second annual National Gas Power Show, given by the National Gas Engine Association, was held in Convention Hall, Kansas City, Mo., on Aug. 16 to 23. Over seventy exhibits were made and while the majority of the displays were of small engines for domestic and agricultural uses, several manufacturers of power engines were represented.

PERSONALS

W. E. Sanders, formerly with the Tagliabue Manufacturing Co., New York City, is associated with the Paul B. Huyette Co., Philadelphia, as mechanical engineer.

Lawrence W. Cody, formerly chief electrical engineer of the Browning Engineering Co., Cleveland, Ohio, has opened an office at 1557 Robinwood Ave., Lakewood, Ohio, and is engaged in consulting and designing work.

George Best, president of the Best Manufacturing Co. for 12 years, has severed his connection with that company and, with his son, George H. Best, has organized the Best Pipe Engineering & Supply Co., with office at 3026 Liberty Ave., Pittsburgh, Penn., to engage in the manufacture and sale of pipe, valves, fittings, etc., and design piping systems for all purposes.

Charles H. Moyer, for 20 years New York manager and chief traveling representative of the George V. Cresson Co., Philadelphia, and in the last few months of its successor, the Cresson-Morris Co., has resigned his position. Mr. Moyer, who is widely known as a specialist in power-transmission machinery, was connected with the George V. Cresson Co. since boyhood and held various positions at the works before opening the New York office. He contemplates going into business as a special engineering representative and manufacturers' agent with an office at 90 West St., New York City.

Nicholas F. Brady, son of the late Anthony N. Brady, has succeeded his father as president of the Edison Electric Illuminating Co., of Brooklyn. J. C. Brady, another son, has been made a director and vice-president to fill the vacancy created by the elevation of Nicholas F. Brady.

POWER

Vol. 38 NEW YORK, SEPTEMBER 9, 1913 No. 11

"Engineer" or "Greaser"?

When an engineer is alluded to as a "greaser" we may rightly assume that the humorist is the bigger and stronger man. It requires might, brawn and muscle to be ingenuously truthful even after one thousand nine hundred and twelve years of Christian influence, for truth is often harsh and uncompromising.

"A greaser is a man that greases or oils machinery," says my dictionary. "An engineer is one that cares for, repairs or erects engines and their auxiliaries." Had the dictionary writer compiled his vocabulary for the sole use of engineers he would have in (a) and a (b) meaning to the word "greaser," or he might have left the word out altogether for no one in the trade would have to turn to it to understand both interpretations.

"Greaser or engineer! To which class do I belong?" is the natural query. "Have I the qualifications to be classed as an engineer under the Webster-an definition? Should I froth at the mouth and grip tighter my wrench when the derogative name 'greaser' is applied to me? Were a duck to waddle into the engine room and squawk, 'Quack!' under my nose, would I be justified in masticating goose bones at my next day's lunch?"

Let—me—see.

If the eccentric of my engine slipped, can I intelligently reset it? If I cannot, I am a "greaser." If the load is suddenly thrown off or the governor belt breaks, will the engine run away? If it will, "greaser" and not "engineer" properly applies to me.

Do I know the steam consumption of my engine, and how favorably (or otherwise) it compares with the known economy of others? If I do not, I am not an engineer. Does my engine thump and pound, and my valve-gear rattle? If they do, I am the opposite of an "expert"—a quack. Many more—very many more—are the questions which I, and you, could ask, and on candid answers will depend our claim to that which the uninitiated public terms us, "engineers."

I was lost in this self-examining mood when a visitor entered the engine room and asked: "Are you the engineer?" I suppose he wondered why I flushed, hesitated and faintly stammered "Yes." Thereupon he asked me to show him around the plant. When this was done, no doubt he was able to judge for himself, whether or not I was an "engineer."

Apropos of this, here is a little poem by Herbert Kaufman that is worth reading:

SHOW US

You say that you *deserve* success;
Pitch in, and start to *show* us.
We think that you deserve *far less*,
And *ought* to be *below* us.
It's up to *you* and what you *do*,
Mere empty *words* won't *change* our view.
Come, prove our viewpoint isn't *true*!
Results are all that we will *count*;
If you can *climb*, begin and *mount*;
Present your case—we're on the jury;
But *all* of us are from *Missouri*.

Will your plant stand the test of "Show us"? Will its condition indicate that "greaser" is the right term to apply to *you*?

[*Written by R. O. Richards, Framingham, Mass.*]

Operating Boilers under Difficulties

By F. J. Raylin

SYNOPSIS—Difficulties encountered in operating a steam plant in the winter while installing four additional boilers. Steam gages and water columns froze and frozen fuel was used while installing a conveying system.

The boiler plant of a large railroad shop, consisting of eight 250-hp. water-tube boilers, was too small to carry the heating and power load, and four more boilers were added. An extension on the north end of the boiler room to accommodate them and leave space for a future addition of four more was built.

Fig. 1. Boiler Room from East End

On account of various delays the work was not well under way until cold weather, at which time the boiler-room roof was off and the entire west end of the boiler plant was exposed to the elements. A rough shed was built over the west and north ends of the plant, but in severe weather the temperature frequently went down to 15 deg. below zero and the gages and water columns were frozen while in operation.

The coal elevator had been removed and all the coal was brought in by wheelbarrows from the west end of the building on a platform and dumped into the top of the chain-grate hoppers, Fig. 1. It required 25 laborers, day and night, to dig the frozen coal (screenings) from the cars, load into wheelbarrows, dump it into the hoppers and remo the ashes from the pit into wheelbarrows and wheel the out into the cars on the west side of the station. Eigh boilers were in operation from Nov. 1 to June 1, witho interfering with the shop service.

After the building was completed and the four ne boilers were in operation, four of the old settings we torn down and the floor excavate between the old and new batterie The old boilers were thorough cleaned and inspected and horizont baffles substituted for the vertic baffles.

The view of the west side of t power station, Fig. 2, shows the ne coal elevator and storage bin of 70 ton capacity. A pneumatic ash co veyor takes care of the four ne boilers on the north side of t boiler room and will eventually ser the eight old boilers on the south si of the room. A 50-ton ash tank c the west side of the coal bunker di charges the ashes into a car on t coal track.

The resetting of the old boile was accomplished by placing two 2 in. steel I-beams over each end the drums and bolting the old fram work through these I-beams so th the boiler was supported, allowin the excavating to be done under t entire battery at one time. T

Fig. 2. West Side of Power Station

ams could be slid from one boiler to another. The neme materially expedited the work and danger of cident from the excavating was minimized.

The horizontal baffles have entirely eliminated the oke from the reset boilers. Analysis of the ash from ese two settings showed 24% combustible from the old le and 10% in the ash from the new-style setting.

Fig. 2 shows the two stacks in operation with four ilers on the old and four boilers on the new one. Coal is received in drop-bottom cars and is unloaded into a hopper under the track at the west end of the station. Thence it goes through a coal crusher and is elevated to the storage bin. Drawn from the bottom of this bin into a 7-ton trolley car, it is distributed to each individual furnace, the hopper of which holds approximately 1½ tons. This plant consumes on the average 200 tons of washed screenings per day during severe winter weather and 125 tons during the summer.

Factors of Safety and Insurance*

YNOPSIS.—An appeal for higher and more uniform tes for boiler and flywheel insurance and casualty lines general.

Factor of safety in engineering is the ratio of breaking rength to safe load. Correspondingly, factor of safety insurance is the ratio of underwriting profit to premium come. A successful engineering structure must have a ir factor of safety, and likewise a successful line of insurance must produce a fair underwriting profit.

In engineering a hazardous structure demands a high ctor of safety, and likewise in insurance a hazardous ne demands a high margin of profit. The underlying ason is the same in both instances. In engineering the ctor of safety takes care of variations in the supposed rength of the material, variations in workmanship, and nditions unforeseen at the time the structure was degned. In insurance the margin of profit takes care of riations from the general average for that particular zard, incomplete or misleading information given to e underwriter, and conditions unforeseen at the time of ting the risk.

An assumed factor of safety in engineering is composed two parts, a real factor of safety, and a pure factor of norance. An assumed factor of safety in insurance is kewise composed of these two parts.

Engineering Factors of Safety

These remarks may be exemplified as follows: For a eel roof truss a factor of safety of three is sufficient, beuse the maximum loading expected to be imposed upon in service can be estimated beforehand, and because e strength of structural steel is uniform and dependble.

For a steam boiler a factor of safety of five should be nployed, because the strength of boiler steel is not uniorm, even in different parts of the same plate, because e strength is affected by the heat of the furnace, beuse the workmanship on the boiler cannot be depended on, and because the safest of boilers is a dangerous enace to life and property.

For flywheels a factor of safety of ten on strength ould be employed because they are made of cast iron, a aterial of such uncertain strength and low ductility that may easily be fractured, because dangerous shrinkage rains are set up when the wheel is cast, because a factor safety on strength of ten is equivalent to a margin of fety on speed of but little more than three, because the safety of the wheel is dependent upon governing mechanism which may get out of order and allow the wheel to race, and because a rotating flywheel is a dangerous menace to life and property.

Insurance Factors of Safety

The insurance factors of safety in liability risks, in workmen's compensation risks, in steam-boiler risks, and in flywheel risks are largely dependent upon the engineering factors of safety. For example, if a roof falls, a boiler explodes, or a flywheel disrupts, the engineering factor of safety is wiped out and likewise the resultant property loss and personal injury damages may be sufficient to wipe out the insurance factor of safety. The insurance factor of safety is also largely dependent upon the number of risks in force, because the premium income from a small number of risks might not contribute enough in the lifetime of a company to pay for a single disastrous loss. The factor of safety in insurance also depends upon many other things, most important of which is a well devised system of accident prevention, and not the least important of which is efficiency of management.

Boiler- and Flywheel-Insurance Factors of Safety

Compared with other lines the volume of boiler insurance written is small, the annual income of all companies combined being only $2,568,000—and the engineering factor of safety is high. Correspondingly, then, the insurance factor of safety should be high. It is, however, now so low that it is exceedingly difficult for even the larger-volume companies to show an underwriting profit. That smallness of volume seriously affects its factor of safety is shown by the interesting experience of a company that has a volume of boiler insurance approximating only $20,000 annually. During one year it had a loss ratio of only 1 per cent., and during another year it had a loss ratio of nearly 140 per cent. That is to say it paid out for losses alone 40 per cent. more than it received in premiums.

The total volume of flywheel insurance written annually is even less than the total volume of boiler insurance; and the engineering factor of safety for flywheels is greater than the engineering factor of safety for boilers. Correspondingly, then, the factor of safety for flywheel insurance should be higher. This is confirmed by the fact that the combined loss ratio of all companies on flywheel insurance is higher than their combined loss ratio on boiler insurance. That smallness of volume seriously affects its factor of safety is shown by the experience of a company that has a volume of flywheel in-

*Abstract of a paper read by W. H. Boehm before the International Association of Casualty and Surety Underwriters.

surance approximating only $4000 annually. During one year it had a loss ratio of nothing, while during another year it had a loss ratio of over 300 per cent. That is to say it paid out for losses alone three times as much as it received in premiums.

Another company having an annual income of only $1000 from flywheel insurance, during one year had a loss ratio of nothing, and during another year had a loss ratio of nearly 1000 per cent. That is to say, it paid out for losses alone nearly ten times as much as it received in premiums. It is interesting to note in passing that even the larger-volume companies are sometimes hard hit. For, during the first three weeks of this year, a company that writes a large volume of boiler insurance sustained losses from three boiler explosions that aggregated nearly $200,000. It is readily seen from this how easy it would be for a single disastrous explosion to more than wipe out for a number of years an estimated underwriting profit of 5 to 10 per cent.

Factors of Safety for Casualty Lines in General

Extracts from the financial statements for 1912 of companies transacting various casualty and liability lines indicate that of the 69 companies transacting these lines, 36 sustained an underwriting loss; and the combined results of the entire 69 companies showed a net underwriting loss of 0.6 per cent. Great variations are observed in the percentages of underwriting profits and losses, ranging from a profit of 41.8 per cent. to a loss of 158.4 per cent. of the premium income. Grouped under the head of each line written, casualty companies show an underwriting loss of 1.5 per cent., surety companies a profit of 1.8 per cent., plate-glass companies a profit of 6.9 per cent., and remaining companies a loss of 0.5 per cent.

During the past ten years the combined underwriting profits of these 69 companies steadily decreased. The vanishing point was reached in 1911, when there was a substantial underwriting loss. The loss in 1912 was even greater than in 1911, from which it is apparent that something must be accomplished to better the factor of safety, if stockholders are to receive a fair dividend on their investment and policyholders are to have proper guarantees for the payment of future losses.

Steam-Boiler and Flywheel Insurance

The steam-boiler and flywheel business has been in more or less of a demoralized state ever since the competitive writing of these lines began. There has been no coöperation as to insurance requirements for the proper construction and safe operation of boilers and flywheels; and there has been no interchange of experience or statistics, or opinions as to the rates for which steam-boiler and flywheel insurance could be written with safety. Company after company has entered the field, depressed rates, demoralized the business generally, and then retired. The cost of boiler and flywheel inspection has steadily increased on account of the increase in the hotel and traveling expenses of inspectors, and the increasing mass of data required to be placed on file by state authorities. The loss ratio has increased on account of the greater amounts that must now be paid for personal injury losses under the new liability and workmen's compensation laws, and for other reasons. Rates have steadily decreased until they are now too near the danger line.

Bettering the Factor of Safety

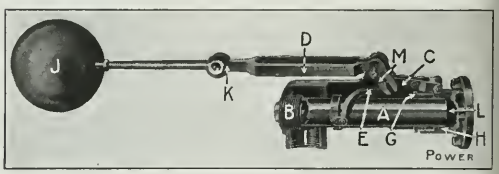
The remedy for this condition, not only as respects steam-boiler and flywheel insurance but as respects other lines of the casualty and surety business, lies in coöperation. It is essential for the mutual interests of all the the companies may be compiled, and equitable rates based and that a bureau be maintained for each line of insurance transacted, in order that the combined experience of all the companies be compiled, and equitable rates based upon this combined experience be formulated, and strictly adhered to. Printed manuals containing such rates may be used by the companies jointly, not necessarily because of any agreement among themselves to do so, but solely because they believe them to be right rates.

There has been formed by company members of the National Association of Casualty and Surety Underwriters a steam-boiler and flywheel service and information bureau. The organization of this bureau is now nearly complete, and it is expected to be in full sway some time in September.

⁂

Ideal Automatic Float Valve

This valve is designed to automatically control the height of water in tanks and reservoirs and can be adjusted to maintain the water at any desired level. In the sectional view, shown herewith, the water enters the tubular-valve *A* at the inlet *L*. When the valve is closed



Ideal Float Valve

the pressure comes against the leather seat *B*, which can be renewed by removing the plug.

When the water in the tank lowers, the float *J* carries the end *M* of the lever *D* upward, which moves the toggle *C* with it. As the toggles *C* and *E* are attached the movement carries the valve *A* away from its seat and water will flow through the outlet *I*.

The float *J* is adjustable at *K* and can be operated at any angle. The valve passes through a stuffing-box *G*, containing square flax packing *H*. The valve is made in sizes from 1 to 2½ in. by the American Steam Gauge & Valve Manufacturing Co., Camden St., Boston, Mass.

⁂

The decline in shipbuilding during the five-year period between 1904 and 1909, according to the Census Bureau, is clearly brought out by the fact that for all classes of vessels of five tons and over there was a decrease, with the exception of motor boats, which formed a small part of the total number reported. The decline in the iron and steel branch of the industry is no doubt due to the decrease in government work done in private shipyards. The increase in the number of small boats constructed is perhaps the most noteworthy fact. Motor boats of more than five tons increased 189.9 per cent. in gross tonnage from 1904 to 1909. The number of small power boats of less than five tons launched by private establishments in the shipbuilding industry was 8577 in 1909, as against 1687 in 1899, an increase for the decade of 408.4 per cent. Practically all the boats of this tonnage are fitted with internal-combustion engines.

Large Power System in South Africa

SYNOPSIS—The plants of the Victoria Falls and Transvaal Power Co. deliver over five million kilowatt-hours annually to the great mining industries in that section. About fifty thousand horsepower is delivered by compressed-air transmission, the greatest distance in this case being eighteen miles, the remaining power is transmitted by high-tension current.

Notably important are the installations of the Victoria Falls and Transvaal Power Co. in South Africa which, after but four years of operation, have reached an annual delivery of five million kilowatt-hours with the not far distant probability of ten millions. In load capacity they rank not only first among public power plants for industrial service but are the only ones delivering a large part of the energy great distances in the form of compressed air; this service alone amounting to 50,000 hp.

From a report of an investigation made in 1905 as to power needs, the gold fields of Witwatersrand extending east and west from Johannesburg a total distance of some 50 miles with an average width of about six miles undoubtedly comprise one of the greatest industrial districts on earth. The number of mines in operation on June 30, 1905, was 66 and the machinery exceeded 200,000 hp. Of this power production only about 25,000 hp. was electric and practically all the rest was steam. An average for 24 mines reported 1.62c. per i.hp.-hr. as the cost of power, which, expressed in electrical units, assuming a steam-engine efficiency of 85 per cent., shows a cost of 2.52c. per kw.-hr.

The figures showed that the operating conditions peculiar to Witwatersrand, more than elsewhere, urged the centralization of power production. The great consumption density and the otherwise hardly attainable high load factor were in this case forceful elements in favor of distribution from a large power house.

First of all a design was worked out for the transmission of compressed air and electricity. The main plant was designed for 70,000 hp. and in addition to the Eckstein mines was to serve those of the Consolidated Goldfields group. At the same time the current price was estimated at 0.9c. per kw.-hr.; whence it would have paid to have supplanted already existing steam plants by electric drives. The air was to be compressed in a large central compressor plant and delivered to the mines through a system of piping under a pressure of about 120 lb. The electric long-distance transmission system was to be overhead.

The argument for this plan was that the direct transfer of compressed air would yield a higher efficiency than electric transmission for the operation of individual compressors by means of electric motors at each mine.

Coincident with the efforts of the Allgemeine Elektricitäts Gesellschaft, though independent thereof, the Chartered Co. also took up the question of power supply to the Rand territory with a view to utilizing the vast power possibilities of the Zambesi at Victoria Falls. To this end rights were acquired from the Chartered Co. to erect at the Victoria Falls site a power house with a capacity of 250,000 hp. The need of an exhaustive investigation into the means to be taken to make it economically and technically possible to transmit this service over the distance of 680 miles, led to the formation of a committee of experts which included Blondel, of Paris, Gisbert Kapp, of Edinburgh, Lord Kelvin, of London, and Tissant, of Basel.

Though this project was not carried into effect, the experts recommended a high-tension three-phase transmission having a constant-current intensity and a variable voltage; the service to be thus varied by means of automatic regulation of the pressure, the upper limit of which was placed at 100,000 volts. The disadvantage of constant copper losses, particularly noticeable at light loads, was negligible because a load factor of over 80 per cent. could be counted on and because there was at hand a water power otherwise unutilizable during such light loads.

With the incorporation of the Victoria Falls Power Co. in 1905, the Allgemeine Elektricitäts Gesellschaft assumed the development of the different projects and all construction. Two power houses with a total capacity of 18,000 kw. were decided on as the initial installation. The smaller plant, with two 3000-kw. units, was to be erected at Brakpan in coöperation with the Rand Central Electric Works and the other with four 3000-kw. units at Simmerpan, because only at those points two large artificial ponds were available for the necessary water.

The Brakpan and Simmerpan Works

The Brakpan works are situated in the extreme easterly part of the Rand. The extent of the installation was restricted at the start by the water supply for condensing purposes. The plant consists of two turbo-generators of 3000 kw., which were originally wound for 10,000 volts, but later were rebuilt for low voltage and transformer inclusion because the high-tension winding was too much endangered through the heavy atmospheric discharges.

There are eight B. & W. marine-type boilers with a normal delivery capacity of 17,000 to 22,000 and a maximum of 30,000 lb. of steam per hour at a temperature of 600 deg. F. Green economizers and artificial draft on the ejector principle are provided with two boilers to a stack. The efficiency attained in operation lies between 77 and 80 per cent. and a preliminary test made in Glasgow showed 83 per cent. The blowers are driven by direct-connected electric motors and the draft is regulated by dampers. The natural draft is sufficient for about 40 per cent. of the boiler duty. For fuel, dust coal is used with a small admixture of fine coal; the heat value of this fuel being from 9000 to 10,800 B.t.u. The voltage is stepped up to 40,000 volts and the current is transmitted exclusively by overhead systems.

At the Simmerpan works there are two boiler houses, each with eight boilers of a unit hourly capacity of 19,800 lb. Each boiler house serves as an initial installation, two turbo-generators of 2000 kw. capacity. In the steam lines the ordinary separators did not prove sufficient, inasmuch as at first through frequently occurring short-

*Translated and abstracted by W. F. Monaghan from a contribution in "Zeitschrift des Vereines Deutscher Ingenieure," by Dr. G. Klingenberg.

circuits water was carried over to the turbines. They were on that account displaced by receiver separators which serve not only for their intended purpose but, at the same time, act as heat reservoirs to reëvaporate the entrained water.

It may be noted that the two-generator booster used to charge the battery is driven by a synchronous motor which is operated by the battery in case of interruption of the power plant and is employed to actuate the auxiliary motors. To this end the battery is designed for short periods of heavy load. This arrangement has proved well justified, serving to operate the auxiliary machinery when other sources of current were not available.

Midway between Brakpan and Simmerpan is situated the main switch and transformer station, or substation, and through which pass both the 40,000-volt lines. The voltage is there stepped down to 10,000 and, as at Brakpan and Simmerpan, there are local distribution systems.

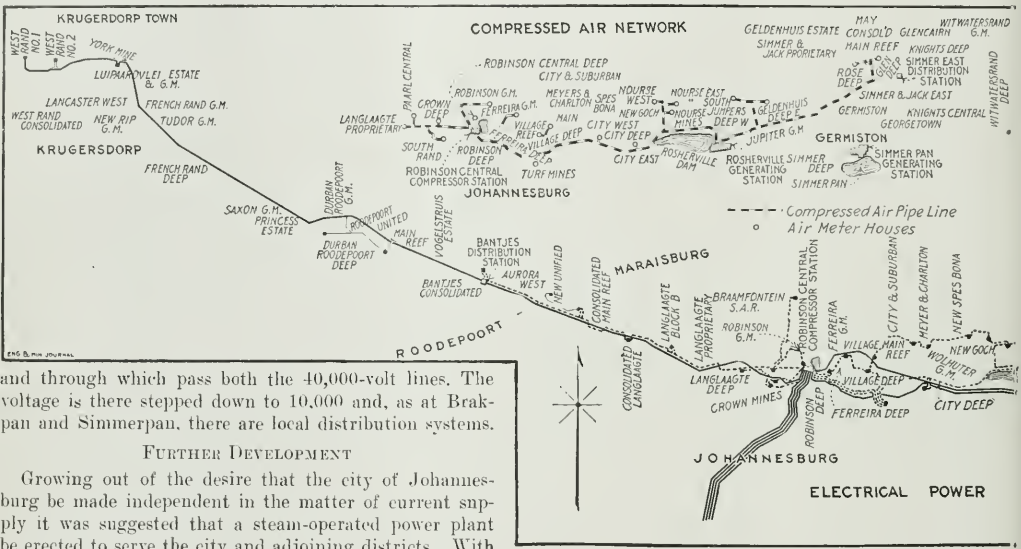


Fig. 1. Map of Power Distribution

Further Development

Growing out of the desire that the city of Johannesburg be made independent in the matter of current supply it was suggested that a steam-operated power plant be erected to serve the city and adjoining districts. With this object in view, negotiations were conducted with different mining companies and, while the Victoria Falls Power Co. prevented the accomplishment of a contract with the city, the plan was successful in that the largest of the mining interests, the Eckstein group, entered into an agreement for current delivery—probably the most important of its kind ever consummated with a single consumer. Outside of a guaranteed minimum yearly consumption of 80 million kw.-hr., the Eckstein concern pledged itself for its total power needs, and, in addition, all machinery should be ready for electric operation by the time the new power plant was finished.

About 40 per cent. of the service was to be through compressed air. To arrive at this air service, investigations were made, and in particular the conversion factor for one kilowatt of air service was determined from the formula

$$1\ kw. = \frac{1}{n}\frac{g}{1000}\,p_o v_o\,log_e\frac{p}{p_o}$$

as a function of volume, pressure and temperature. The constant $\frac{1}{n}$ was to be determined by efficiency tests of existing compressor plants. The price agreed on for a kilowatt-hour of electricity was 0.89c. and for a kilowatt-hour of air 1.33c.; subject to a decrease if the freight charges on the coal were lessened.

The contract with the Eckstein mines was later extended to 20 years and the guaranteed minimum current consumption was raised from 80 to 130 million kw.-hr. per annum.

Lacking government consent for the introduction of foreign current into the Transvaal, withheld for the protection of the coal-handling interests, the utilization of the Victoria Falls was impossible and the corporate name was changed to the Victoria Falls & Transvaal Power Co. A new contract was entered into with the Allgemeine Elektricitäts Gesellschaft for the construction of new power houses with a service capacity of 84,000 kv.-a. in steam turbine units and 40,000 hp. in air compressors, and the necessary overhead transmission lines for 40,000 and 10,000 volts, an underground cable system for 20,000 volts and an extended piping system for 128 lb. pressure. Meanwhile, through the taking over of two new mining companies, the power need of the Eckstein group had increased to 320 million kw.-hr. To be added thereto was the very considerable power consumption by the Goldfields and Albu groups which had, in the meantime, signified their readiness to be included in the service, so that to begin with, a consumption of about 500 million kw.-hr. could be counted on.

The coal found in the Rand territory lies at moderate depth and is of low grade, though when mixed with the better grades it is available for use with the chain-grate stoker. The most important coal deposits are in the Witbank-Middleburg district, about 200 miles east of Johannesburg. The coal is good and has a heat value of 11,500 to 12,600 B.t.u.

Roshervilledam and Robinson Central Plants

The power plant at Roshervilledam consists at present of 32 boilers of 33,000 lb. hourly evaporative capacity

each, or a total of 1,056,000 lb. per hr. The engine house contains five turbo-generators, each of 12,000 kv.-a. capacity at 5000 volts and six 4000-hp. turbo-compressors. The exhaust from the auxiliary turbines is discharged into the second stage of the main turbines and the exhaust from the turbines operating feed pumps is used for heating the feed water.

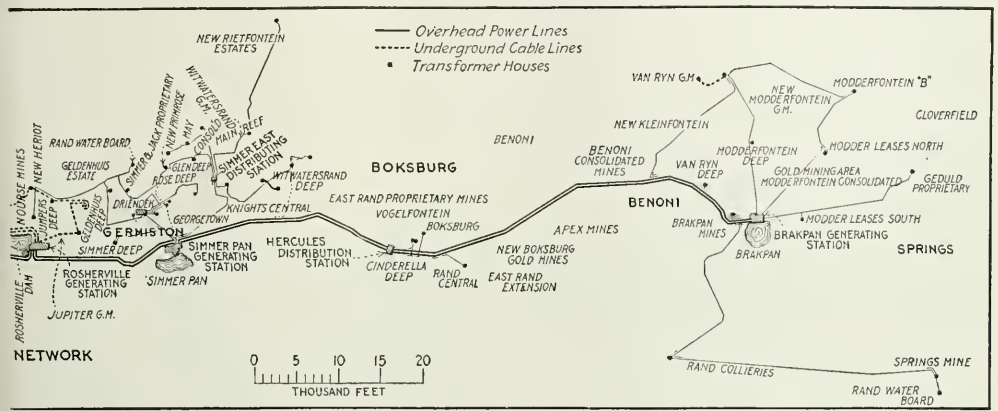
The same provision is made here as in the other plants for the operation of the auxiliaries by use of the synchronous motor of the storage-battery generator set; the auxiliary transformers being automatically disconnected from the busbars on the resumption of the main current supply.

The Robinson Central Works form a subsidiary installation about five miles west of Roshervilledam. It is not a generating station and current is supplied to it from Roshervilledam by four 40,000-volt overhead conductors and from Vereeniging by three 80,000-volt conductors and stepped down as needed.

The air is supplied by turbo-compressors of which six 4000-hp. units comprise the initial installation. Each unit is made up of two parts of two cylinders each and each part is operated by means of a direct-connected, drawn from the Robinson pond and delivered through a duplex coke filter.

Of the 320 million kw.-hr. for the Eckstein group, about 40 per cent. was to be furnished in compressed air. From the determined load factor, and with inclusion of the 25 per cent. reserve on call, this quantity of air indicated a mechanical duty of around 50,000 hp. The maximum transmission distance for the air is a little over 18 miles. Previous to this installation the compressed-air plant then in operation at Paris had a duty of approximately only 8000 hp., and the largest reciprocating compressor built for the pressure in question had a capacity of but 1500 hp. The designing of rotary compressors was still in the early stages of development and satisfactory results were at hand only for small loads and air lines of only approximate measurements, for such pressures had not previously been used. Even the pipe couplings, required over three months in their development, as the Paris type had proved unsuitable. These couplings had to meet the following severe requirements.

(a) They must serve as stuffing-boxes as the pipe lines are exposed to great temperature changes.



Systems on the Rand, Showing Air and Electric Transmission Lines

2000-hp. synchronous motor, this method of drive being preferred because the load factor of the whole system is thereby improved. An installation of special motor-generator sets is provided for starting the compressors; the motors of these sets being synchronous.

In starting, the generator of a set is first electrically connected with one of the motors of the compressor unit and both the generator and motor are then fully excited; upon which the generator is slowly set in motion. The synchronous motor of the compressor is carried along with it, the suction valve being closed and the compressor running light, and after a speed of 3000 r.p.m. has been reached it is cut into the system, in the usual way for synchronizing, and the starting generator is then thrown out. This procedure is repeated for starting the other motor of the compressor unit. The service necessary for the starting of the individual halves of the compressor units lies between 400 and 600 kw.

It is important that the piping system should be supplied with the cleanest possible air, and good filtering plants are installed. A special pumping plant provides the water for cooling the compressors, the supply being

(b) They must be easily taken apart to permit of pipe removals.

(c) They must allow direction changes of 5 to 10 deg., that the line may accommodate itself to surface alignment.

(d) They must, under these conditions and with pipes of a maximum diameter of 24 in. remain tight under a pressure of 128 lb. per sq.in.

The measuring appliances are called on to reliably care for a yearly service of more than a hundred million kilowatt-hours of which the money value for that time is represented by $1,190,000. The necessity for their accuracy and reliability is best measured by the statement that an error of 1 per cent. means $11,900.

In many cases the conditions which governed the installation of the air system were applicable to the electric system, inasmuch as all the Eckstein mines, besides the transmitted electrical energy, used compressed air at the same time, and thus the pipe lines and the electric conductors could often be laid in the same trenches. The systems are in most part buried, overground laying, on concrete columns or posts, being done only on crossing

valleys and marshes, and at such places are covered with corrugated iron to protect the piping against undue heating by the sun. The length of the single line is eight miles of 9-in. to 24-in. pipe. For packing for the stuffing-boxes contour rings of extra-good rubber are used; these corresponding in section to the inside form of the boxes in which they are used. A maximum leakage loss of 2 per cent. had to be guaranteed, and the actual loss from that cause has been found to be somewhat less than 0.5 per cent.

The air service to the different consumers is measured in kilowatt-hours, figured on an isothermic basis, to which end a special meter is installed at each mine which automatically records the work delivered. As air-measuring appliances of the gas-meter type, in which the indicating mechanism is influenced by pressure and temperature, would have been of unusual dimensions and complex, it was decided to resort to measurement by means of nozzles of the Venturi design to which were added recording devices taking into account the variation of pressure and temperature. Each manometric and thermometric spring, governed in its movements, respectively, by pressure and temperature, actuates a logarithmic cam; the movements of both are added by means of gearing; the sum is transferred to an anti-logarithmic cam, and the indicating mechanism thus gives the product of both movements. These meters have proved to be very satisfactory under all operating conditions.

A New DeLaval Velocity-Stage Turbine

SYNOPSIS—The turbine consists of two regular DeLaval wheels with a row of reversing blades between. The reducing gear is still retained.

For twenty years the DeLaval Steam Turbine Co. has built, and still continues to build, its original high-speed single-stage gear-reduction turbine, since this arrangement offers certain advantages in promoting efficiency by allowing the buckets to travel at approximately the proper velocity relatively to the velocity of the steam

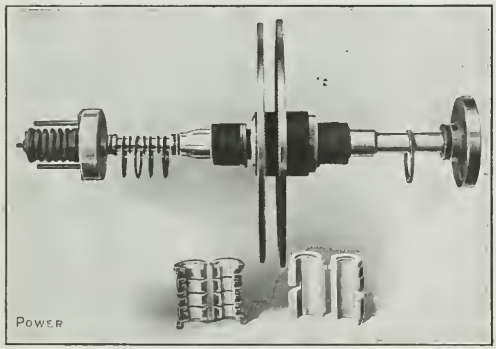


FIG. 1. COMPLETE ROTATING MEMBER AND BEARINGS OF DELAVAL CLASS C TURBINE

jet, while permitting of driving generators, pumps and blowers, and of rope or belt drive without sacrificing the efficiency or reliability of the driven machine by overspeeding. The single-stage turbine, however, has definite limitations as to capacity, that is, with a given-size wheel and speed of rotation, centrifugal force sets a definite limit to the allowable length of the buckets. To evade this limit, that is to build turbines of larger size, the engineers of the DeLaval Co. some time ago introduced pressure stages, as in the new DeLaval pressure staged multicellular turbine described in the June 4, 1912, issue of POWER, although still retaining the reduction gear as the best means of effecting the compromise between the best turbine speed and the best speed of the driven machine. Only enough stages are introduced to reduce the speed of the turbine sufficiently to allow of lengthening the blades to secure the desired capacity, the remainder of the speed reduction being left to the gear. Inasmuch as there are many services, such as in driving small pumps and blowers, exciters, etc., where the additional cost and complication of gears and pressure stages are objectionable, and where high steam economy is not so important, since the turbine may exhaust into open feed-water heaters or into heating systems, the DeLaval Co. has perfected a line of velocity-stage turbines.

Two DeLaval wheels made in the regular DeLaval way by inserting the buckets as shown in Fig. 2, are

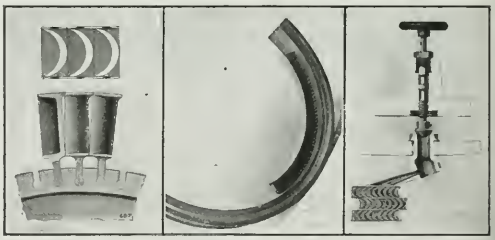


Fig. 2 Fig. 3 Fig. 4

FIG. 2. METHOD OF MOUNTING BUCKETS
FIG. 3. STATIONARY GUIDE VANES
FIG. 4. CONTROLLING VALVE, NOZZLE, BUCKETS AND GUIDE VANES

run beside each other as shown in Fig. 1 upon the same shaft, the one further from the nozzle having longer blades to allow for the passage of the same volume at a diminished velocity. A row of similar blades set into a steel ring, as shown in Fig. 3, is placed between these two wheels so that the steam follows the course indicated in Fig. 4 as in the regular Curtis turbine. The high-pressure steam is admitted to the box on the side of the casing only, and only the lower-pressure steam after it has expanded through the nozzle has access to the interior of the casing. Each nozzle is controlled by a handwheel accessible from the outside as shown in Fig. 5, so that more or less nozzles may be put into action according to the service to which the turbine is to be put and the nozzles which are in play will be under the action of the throttling governor, the moving parts

of which are completely incased in the stationary casing. The usual emergency governor is of course included.

The buckets both of the rotor and stator are individually removable so that they can be quickly replaced and the ring carrying the stationary bucket constitutes

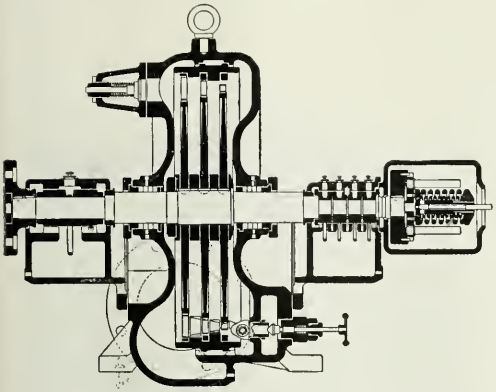


Fig. 5. Longitudinal Section through "NC" Turbine

an effective stop against the flying of pieces should breakage occur. The housing is divided horizontally and the top has no piping or other attachment, but is simply a cover which may be easily removed, exposing the working parts. The shaft is carried in two ring-oiled bearings (see Figs. 6 and 7), one of which is a thrust bearing by which the axial position of the shaft and

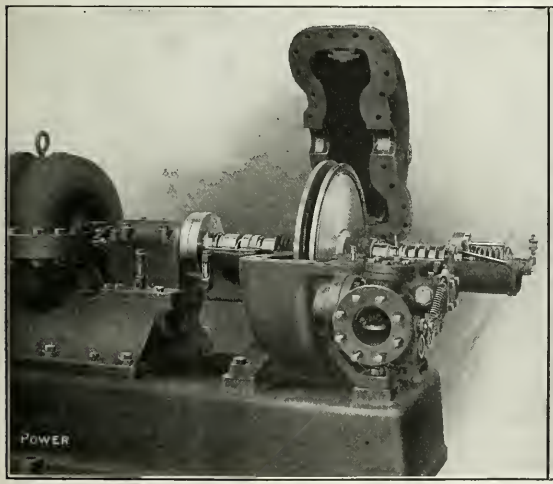


Fig. 6. The Turbine with Bearing Caps and Cover Lifted

the relations of the moving and stationary buckets are fixed. The bearing brackets are supported directly on the turbine casing and are separate from the stuffing-boxes.

Instead of carrying the two crowns of moving blades upon a single disk, as is usual with builders of the Curtis type, each row of moving blades is carried upon its own disk, which is thus subjected to the centrifugal force due to the mass of a single row. The turbine, in fact, consists of two regular DeLaval wheels with a row of reversing blades between them. Each part that can be worn or eroded is machined to limit gages and interchangeable so that it may be quickly and cheaply replaced. The only way in which high pressure could accumulate within the casing would be through the stoppage of the exhaust outlet. To guard against any accident from this cause, a relief valve is fitted to the upper part of the casing cover, as shown in Fig. 5. If the turbine is to be operated with superheated or high-pressure steam having a temperature of 450 deg., F., or over, the parts of the governor valve and safety-stop valve coming in contact with the high-pressure steam are made of steel.

Long experience with high-velocity steam jets has convinced the builders of the DeLaval turbine that the most satisfactory form of bucket to resist erosion is a drop-forging of metal having a high resistance to corrosion or erosion upon which the original scale, formed in the drop-forging process, has been allowed to remain. The buckets of the present turbine are made of nickel bronze by this process and are inserted in the rim of the wheel by bulb shanks fitted into slots milled and bored in the rim transversely to the plane of the wheel, as shown in Fig. 2, a mode of attachment which has been thoroughly tried out in the DeLaval turbine for years. The guide blades are similarly formed and secured.

With ordinary noncondensing operation the packing of the stuffing-boxes is a simple matter, as there is practically an equal pressure inside and outside of the casing.

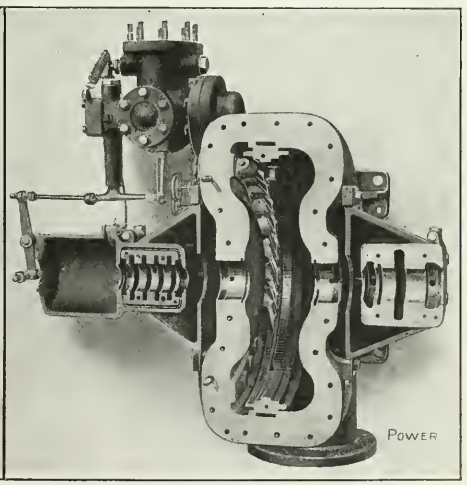


Fig. 7. Turbine Case after Rotating Parts and Bearings Have Been Removed

Where condensing operation is contemplated the provision of efficient packings about the shaft becomes an important factor and in the present turbine a soft packing has been adopted with provision for steam or water sealing. The turbine in this form is available in capacities of from 1 to 750 hp.

Elliott Twin Heater

Engineers have frequently encountered operating conditions such that a twin heater would have been a valuable adjunct to the plant equipment had it been installed, which would have enabled one-half to have been cut out for cleaning, etc., while the other half was carrying the load. The Elliott Co., 6908 Susquehanna St., Pittsburgh, Penn., has recognized the advisability of such a heater, and is now manufacturing what is known as a twin heater, consisting of two heaters in one, comprising a heating chamber divided into two parts by a partition.

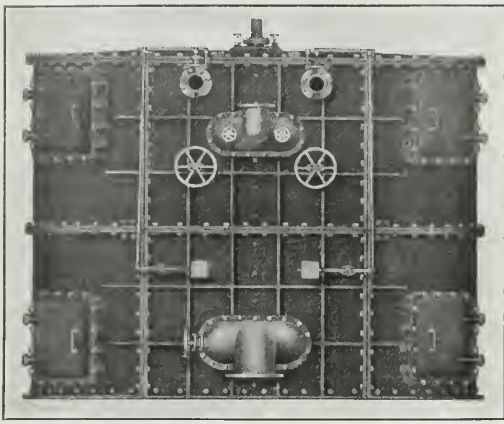


FIG. 1. FRONT ELEVATION OF TWIN HEATER

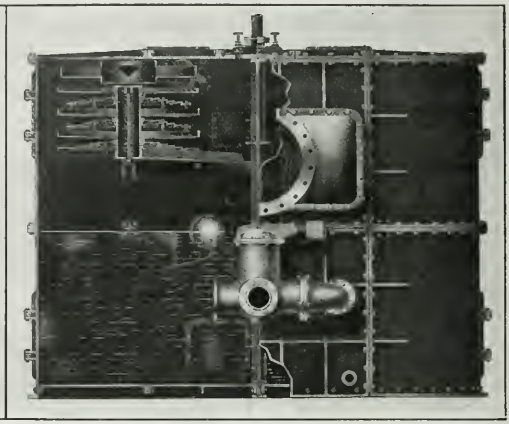


FIG. 2. HALF SECTION OF TWIN HEATER

It is so designed that either side can be operated independently, or both sides can be operated conjunctively. Each compartment has its own steam inlet, oil separator, cutout valve, pans, water inlet and outlet, overflow, etc. As each inlet and outlet is provided with a valve which is a part of the heater, it is only necessary to place it on the foundation and connect up the exhaust, feed-pump suction and blowoff lines. Fig. 1; a front elevation of a twin heater, shows the clean-out doors and the various connections. Fig. 2 is a rear view and half section of the heater.

As the complete valve equipment and connections form a part of the heater, it makes a compact piece of apparatus, and reduces the cost of piping.

In operation the steam enters the main inlet nozzle which communicates with the two inlet nozzles on the two sides of the dividing wall, where it comes in contact with the combined valve and separators and precipitates the entrainments into the overflow box below. If the heater is carrying back pressure a trap is attached to the two overflow boxes and serves as a means for sealing the openings; at the same time it automatically discharges the condensation water. The trap also relieves the heater of surplus water, should the height of the normal water level be exceeded.

The operation of the float-controlled inlet valve, pans, etc., is identically the same as that described for the cylindrical heaters on page 290 of the Aug. 26 issue. The hot-water outlet is hooded and vented to the steam pipe extending above the top of the water level; the two outlets communicating with the main pump section are controlled by check valves. The heater is vented through the outlet on top which communicates with both sides through openings controlled by valves.

The advantage of this heater is that it is adapted to central stations, office buildings and power plants, where the operation is continuous and where there are light-load periods, during the day or night, when one side can be cut out and cleaned, at the same time maintaining the maximum temperature of the water going to the boilers. All controlling valves are accessible, as they are part of the heater and are especially designed for the purpose intended. The heater is made of cast iron and is capable of withstanding 15-lb. working pressure.

The pump-suction connection extends downward and is provided with a flange. Each side of the heater has

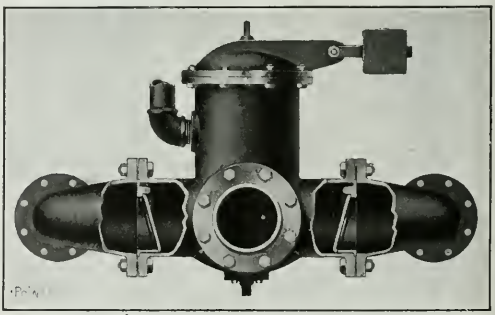


FIG. 3. SUCTION CHECK VALVES

an independent outlet communicating with a common chamber adjacent to the main outlet to the pump suction. The outlets to both sides of the heater are protected by check valves opening in an outward direction, as shown in Fig. 3. The main outlet is also provided with a sliding gate valve, Fig. 4, for completely isolating either side. This valve is so arranged as to shut off either side, making it absolutely independent of the other, but is rarely used except in emergencies as in the event of the

check valve sticking or leaking. The illustration is a top view of the hot-water outlet, showing the valve and vented hoods.

Fig. 5 shows a vertical section of a twin heater and a general arrangement of cutout valves, trap, overflow box, pans and pump suction, also the water supply. The entrainment coming from the separator, also from the

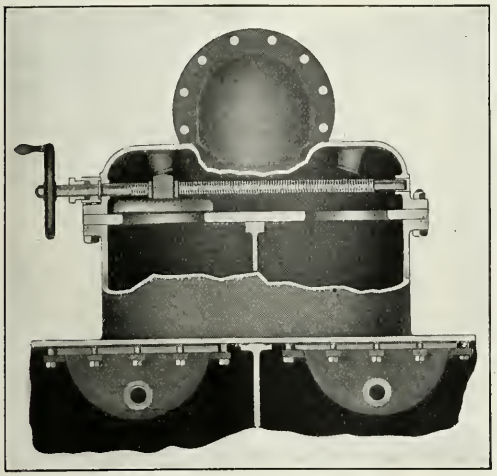


Fig. 4. Sliding Gate Valve

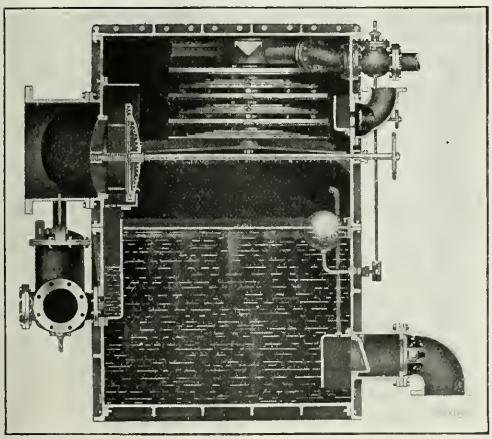


Fig. 5. Section Showing Cutout Valve, Trap, Overflow Box, Pans, Etc.

overflow from the heater, is controlled by a float-actuated trap connected to the outlets and the two overflow boxes located below the steam inlet.

The connection between the overflow outlets and the trap is provided with a check valve opening toward the trap. The trap is vented to the main inlet nozzle. When one part of the heater is out of service, the water in the trap chamber alone, or aided by the back pressure on the opposite side, will cause the check valve on the idle side to remain tight. When it is desired to cut out one side of the heater with this arrangement, it is only necessary to close the cutout valve.

If the heater is used on a heating system the returns are admitted through a single inlet nozzle mounted on the front wall. This nozzle has two valve-controlled branches communicating one to each side of the heater. The return inlets are water sealed and placed in the steam chamber, and the water dropping to the water level has its temperature raised should the incoming temperature be less than that of the steam in the heater.

Otis Elevator Controller-Parts Cabinet

In order to facilitate and quicken repair service in the event of unexpected breakdowns or worn parts on elevator controllers, a controller-parts cabinet for the convenience of engineers is made by the Otis Elevator Co., Eleventh Ave. and Twenty-sixth St., New York City.

It is made of steel, and contains all essential parts of the type of controller furnished with the elevator machine installed. By referring to the descriptive catalog in the box the engineer can determine at a glance just the part needed to replace the broken or worn mechanism. If any of the parts are removed from the cabinet, duplicate parts can be ordered immediately to replace them so that the cabinet will always be complete.

The advantages of having one of these cabinets in the engine room are that repairs can be made on the spot, elevator service will not be impaired, and there is always at hand a remedy for any controller trouble.

Automatic-Release Pen Lifter

This attachment can be attached to any Foxboro improved recorder. It is a simple device, consisting of a German-silver strip mounted on a special holder, inserted under a screw-head which holds the chart disk. A slight pressure on a small lever brings the strip up against the pen arm and lifts the pen from the chart. Friction holds it in the raised position, thus giving the operator free use of both hands for removing the used chart and supplying a new one. When the door is closed, the pen arm is automatically released and the pen returns to its marking position on the chart. This automatic feature makes it impossible for the operator to forget and leave the instrument out of commission.

The device, which is manufactured by the Industrial Instrument Co., Foxboro, Mass., eliminates the necessity of handling the pen arm, with the possibility of affecting the adjustment, due to a slip or accidental strain. It also prevents accidents commonly resulting in spreading ink where it does not belong and is not desired.

Largest Fuel Consumer—The Pittsburgh district of Pennsylvania is the largest consumer of fuel in the world, and in magnitude of coal traffic it is also preëminent. In population Pittsburgh ranks fifth among the cities of the United States, having as "Greater Pittsburgh" only about one-sixth that of Greater New York, but in the consumption of coal alone Pittsburgh nearly equals that of the largest city in the country. It is estimated (no accurate data being available) that Greater New York consumes between 18,000,000 and 20,000,000 short tons of coal annually. The Pittsburgh district in 1912, according to Edward W. Parker, of the U. S. Geological Survey, consumed 17,721,783 tons of coal and about 5,000,000 tons of coke, or a total of about 22,700,000 short tons, over 10% more than all the boroughs of Greater New York. Pittsburgh also consumes millions of cubic feet of natural gas.

ELECTRICAL DEPARTMENT

Aluminum-Cell Lightning Arrester

By John A. Randolph

The function of any lightning-arrester is to accomplish for the electric circuit what the safety and hydraulic relief valves do for mechanical apparatus, namely, the prevention of a rise in pressure above a safe limit. In so doing, it protects the apparatus near it from the disastrous effects of abnormal currents and strains due to the excessive voltages caused principally by lightning.

There are various types of arresters, the choice depending upon the nature and value of the apparatus to be protected, the service performed by the circuit, the working voltage, the kind of current, and, to a certain extent, upon the locality. A type which is used extensively on high-voltage systems consists of the electrolytic or aluminum cell arrester. It consists essentially of a series of aluminum trays, or cone-shaped receptacles, an electrolyte, a quantity of oil and a containing tank.

The receptacle or plate elements are designed to hold the electrolyte and to fit into one another concentrically with a predetermined clearance. The top receptacle is connected to the line through a horn gap, and the bottom one connects to the ground. Various solutions may be used as the principal ingredient of the electrolyte, some of which are dilute sulphuric acid, bichromate of potash and ammonium phosphate.

The action of the arrester depends upon the fact that when an electric current is passed through the series of electrolytic cells, composed of aluminum plates and a suitable electrolyte, a thin film of aluminum hydroxide is formed upon those parts of the plates exposed to the electrolyte. A characteristic of this substance consists in its acting as an insulator or dielectric up to a certain value of the voltage known as the critical value. At potentials above this point, it breaks down and allows the current to flow freely to ground as long as the pressure remains above the critical value. When the voltage drops to this point, the film regains its insulating property and resists the flow of current as before.

As commercially constructed, the receptacles and electrolyte are placed in a steel tank which is filled with oil to a depth sufficient to completely cover the receptacles.

One form of arrester is shown in Fig. 1. The aluminum plates in this case are in the form of circular trays and are placed in a vertical stack in the center of a round steel tank. For convenience in handling, the trays are grouped in sections, each section being sufficiently light in weight for a man to handle. The trays of each section are held together by treated wooden tie-rods placed outside the trays. The sections are held in place by two vertical wooden guides which fit loosely into two slots in the top and bottom clamps. A clearance of about ¼ in. is maintained between the trays by porcelain spacers. The trays are filled with electrolyte to about the depth shown, a quantity being used which is sufficient to permit every tray to make good contact through the electrolyte with its neighbor. The containing tank is made of steel and is large enough to afford sufficient clearance to prevent arcing across between the trays and the tank on discharge. The intervening space is filled with oil which completely covers the trays and electrolyte, and which does not mix with the electrolyte, owing to the higher specific gravity of the latter. By keeping out the air, the oil prevents evaporation of the electrolyte. It also aids in the dissipation of the heat generated by a continuous discharge, owing to its tendency to circulate from points of high to points of low temperature. In addition to the functions already described, the oil serves as an effective insulation between the trays and the sides of the tank. The conductor connected to the contact plate at the top of the tray stack extends through a porcelain insulator mounted in the cover of the tank and is joined outside the tank to a cable or wire connecting with the horn gap.

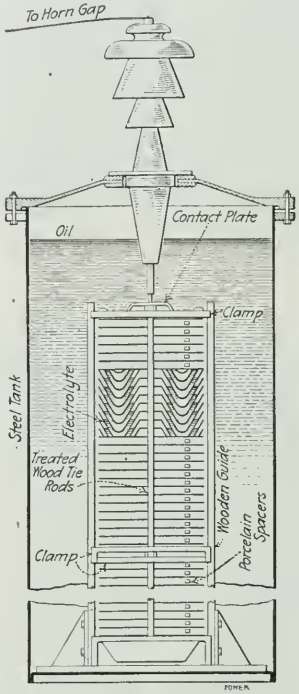


Fig. 1. Partial Section through Cell

The number of aluminum receptacles used in an electrolytic arrester depends upon the normal or working voltage of the circuit protected. On alternating-current lines one receptacle is used for each 275 effective volts. With direct current, one receptacle is used for each 350

olts. The critical or discharge voltage is 300 volts per eceptacle for alternating currents and 420 for direct-urrent circuits.

Aluminum Receptacles

These should be of a contour such as to permit the ree circulation of oil and to allow all bubbles formed

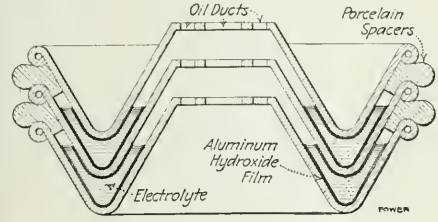


Fig. 2. Detail of Trays

n the electrolyte to pass off without collecting anywhere bout the receptacle. For this reason, the receptacles re so designed that their surfaces are as smooth as pos-ible and free from ledges and pockets which would ollect bubbles or retard the proper circulation of the oil.

The form of receptacle used in the arrester of Fig. 1 s shown to a larger scale in Fig. 2. It will be observed hat the receptacle is made into a form of a tray. Holes or ducts are provided in the central portion for the oil irculation.

Horn Gaps

An inherent quality of the aluminum-cell arrester is hat when connected to the line a current will flow hrough it of a magnitude depending upon the state of the hydroxide film, the receptacles and the electrolyte. It is also dependent upon the resistance, if any, which s used in series with the arrester. If a resistance is used, he current can be made very small. A current, however, even though small, flowing continuously through the rrester, has a deteriorating effect upon the arrester as a whole. An electrolytic action takes place between the luminum receptacles and the electrolyte which results n a gradual deterioration of the receptacles and a wast-ng away of the electrolyte. The heat formed also en-ances the harmful effects of the continuous charge. On ccount of the disadvantages of a continuous flow of urrent through the arrester, it is the general practice o place a spark gap or horn gap, as it is more commonly alled, between the arrester and the line, thus leaving he arrester open-circuited at all times when not charg-ng or discharging. There are also two other results ccomplished by the use of the horn gap: Firstly, it cts as a disconnecting switch whereby the arrester may e easily disconnected from the line for cleaning, inspec-ion and repairs; secondly, it can be used as a switch or connecting in the arrester for charging.

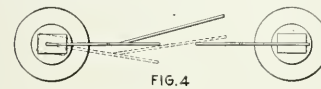
A form of horn gap commonly used on high-voltage ines is shown in Fig. 3. The insulator *A* carrying the orn *C* is mounted upon a pin *D*, which is so arranged hat it can be easily turned by the arm *H*; the insulator *B* carrying the horn *E* is stationary. Fastened to the upporting arm of the horn *C* is a copper strip. Under ormal conditions the two horns occupy the position hown by the heavy lines in Fig. 4. When it is desired to charge the arrester, the horn *C* is turned by the handle *H* to the position shown by the dotted lines, thus bringing the copper strip *F* into contact with the horn *E*. This action shortcircuits the horn gap and thereby subjects the arrester directly to the line voltage, causing a charging current to flow.

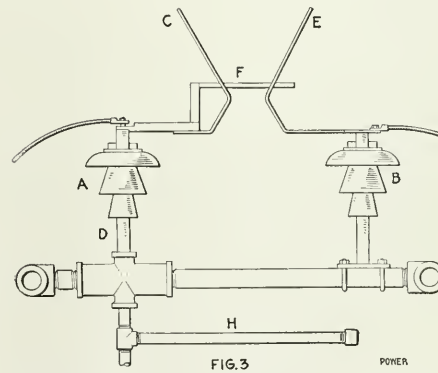
Charging Resistances

Oftentimes arresters are used under conditions such that it is desirable to regulate the charging current to prevent it from being excessive and thereby affecting the equilibrium of the system and injuring the aluminum receptacles as well. This is accomplished by arranging a resistance at the horn gap in such a manner that while charging, it is connected in series with the arrester and the main line.

Charging

The process of charging consists in forming the film of aluminum hydroxide. When once formed it will not last indefinitely, but is gradually dissolved by the electrolyte and, unless regularly replenished, will soon completely disappear, leaving the arrester temporarily useless. For this reason it is necessary frequently to rebuild or replenish the film. This consists simply in allowing a current to flow through the cells and electrolyte by connecting the arrester to the line either directly or through a resistance. The electrolytic action thereby established between the aluminum receptacles and the





Figs. 3 and 4. Showing Elevation and Plan of Horn Gap

electrolyte causes a new film to replace that which has been dissolved. The length of time required for a charge is ordinarily very short, a period of not more than 30 sec. being sufficient under normal conditions.

The intervals between charges depend upon the kind of electrolyte used, and upon the temperature. With the more common electrolytes, a daily charge is necessary. Some electrolytes are made, however, which require charging but once a week. The difference in the time between successive charges for the various kinds of electrolytes is due principally to the difference in the

resistances of the solutions. In those requiring charging but once a week, the resistance is sufficiently high to prevent an excessive rush of current at charging which would otherwise take place as a result of the dissolution of the film. With the electrolytes requiring more frequent charges the resistance is much lower, making it therefore inadvisable to allow more than a day to elapse between charges. The high resistance electrolytes, however, have the disadvantage of lowering the discharge rate of the arrester and are therefore not as desirable nor as generally used as those of low resistance. The temperature of the electrolyte is also an important factor inasmuch as the film will be more rapidly dissolved at high temperatures than at low. For this reason more frequent charges are necessary in warm weather than in cold. The electrolyte freezes at a temperature of about 20 deg. F., the effect of freezing being a lowering of the conductivity with a consequent lessening of the freedom of discharge and a lowering of the efficiency.

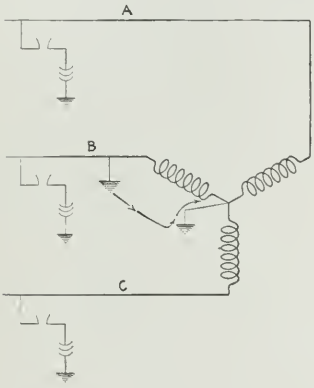


FIG. 5

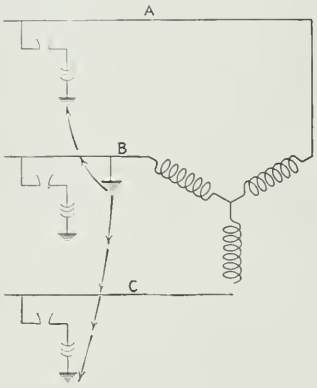


FIG. 6

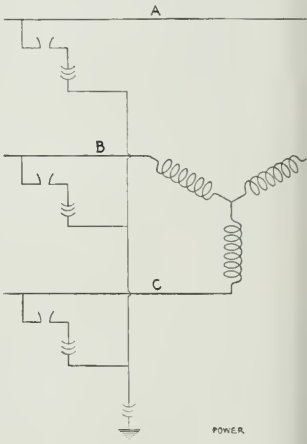


FIG. 7

If, when an arrester is first installed, a period of more than two days has elapsed since charging, or, if already in service, an interval of twice its normal charging period or longer has elapsed since its last charge, it is best not to subject it to the full line voltage at first. This is because, owing to the abnormal dissolution of the film which has taken place, the resistance of the latter will be so low as to permit an excessive rush of current, resulting not only in disturbing the equilibrium of the system, but in overheating and injuring the cells and their connections. To prevent this contingency, arcs should be started across the horn gaps at half normal line voltage. After momentarily making and breaking the arcs ten or fifteen times, the potential should be raised to three-fourths normal, and the same operation repeated. The full voltage can then be applied by a few momentary flashes across the gaps, after which the arrester is ready for service.

Frequently it is not possible to obtain variable voltages for the foregoing procedure. In such a case, the fuses between the arrester and line should be replaced by a piece of No. 30 copper wire or a strand of lamp cord, after which the horn gaps should be short-circuited as in normal charging. The fuses will be blown every time the gaps are bridged until the film has reached its normal condition, after which these improvised fuses will no longer be blown. A bluish crackling static spark at the horn gaps will indicate a normal condition.

The number of separate cell stacks to be chosen for a three-phase alternating-current circuit depends primarily upon whether or not the neutral is grounded. It is necessary to consider the neutral in choosing the arresters because of the results likely to ensue from an accidental grounding of one of the lines. If the neutral is grounded and the oil switches are free to act instantaneously, only three cell stacks are necessary. This can be readily understood by reference to Fig. 5. It will be observed that when one phase *B* is grounded, the short-circuited current will take the direction of the arrows, thus affecting only the grounded phase *B*. On an ungrounded circuit, however, the short-circuited current, under the same conditions, would take the direction shown in Fig. 6, flowing through the arresters to the phases *A* and *C*.

On grounded systems, the arresters are chosen which are designed for only the normal working voltage of one phase. Under the condition shown in Fig. 6, however, the arresters on lines *A* and *C* are subjected to 1.73 times the normal or working voltage to which they would be subjected on a circuit with grounded neutral. This is due to the fact that in the customary Y-connected system the voltage between any two phases is 1.73 times the voltage between any line and the neutral. It is therefore apparent that on an ungrounded system a heavier arrester resistance must be inserted between the lines and ground than on the grounded circuit to protect the arresters against the excessive evaporation of electrolyte and wearing away of the plates that would result from the excessive currents due to grounded lines. This protection is accomplished by connecting the three main-line stacks to a common grounding busbar, as shown in Fig. 7, the latter being connected to a fourth arrester which in turn is connected to the ground proper. By this means the arresters are permitted to discharge the heavy currents due to grounded phases, without being unduly overloaded. To secure the same result without the use of the fourth arrester, it would be necessary to increase the size of the other arresters.

GAS POWER DEPARTMENT

Comparative Cost of Gas and Steam Plants

By L. B. Lent

A very favorable opportunity to ascertain the relative costs of producing electric power with producers and gas engines and with boilers and steam engines has been afforded in a small lighting plant not far from New York City. For several years the station equipment consisted of two anthracite gas producers, two vertical three-cylinder gas engines and two 60-cycle two-phase 2200-volt alternating-current generators, one generator being direct-connected to a 100-hp. engine and the other generator belted to a 60-hp. engine. Each producer was rated at 75 hp. Twenty-four-hour service was furnished.

The load on the gas plant was small during the day and built up to a maximum during the lighting period in the evening, and in 1911 the peak became equal to the plant capacity.

The different characteristics of the two generators, which were of different make, and the difficulty of closely regulating the two gas engines made it almost impossible to operate these generators in parallel with any degree of assurance. Therefore, it was the practice to carry a part of the load on each machine by dividing the distribution circuits.

The rather unsatisfactory experiences incident to operating at maximum capacity led to a decision to build a new station on another site instead of increasing the capacity of the old station. This new station was accordingly built and equipped during 1911 with steam apparatus. The equipment consists of two 200-hp. horizontal return-tubular boilers, delivering their gases through an 80-tube economizer to a radial brick stack 125 ft. high. Steam is delivered to two 14x20-in. 200-hp. simple noncondensing engines at 150 lb. pressure. The engines are direct-connected to 60-cycle, two-phase, 2200-volt alternating-current generators, the exciter units being driven by belts from a pulley on the main shaft of each engine. The usual auxiliary equipment of a feed-water heater and duplicate boiler-feed pump is augmented in this station by a motor-driven fan for furnishing forced draft to the ashpits of each boiler.

The fuel supplied to the gas plant was anthracite pea coal, costing approximately $3.90 per ton, and that at present supplied to the steam station is anthracite No. 3 buckwheat costing approximately $3.50 per ton at the plant.

The present load and that which was carried during the year 1912 by the steam plant is substantially of the same character as that carried by the gas plant, except that it is larger during the entire 24-hour period. In fact, all of the operating conditions in the steam plant are so similar to those in the gas plant as to make a comparison of the cost of power a very fair one. In fairness to the gas plant, it should be stated that the operation was not as economical as was possible. An examination of the ash from the producers showed that considerable fuel passed through unconsumed and other conditions of operation made the fuel consumption higher than it should have been.

Costs

The first cost of the gas plant was as follows:

Building	$3,033.03	
Gas Power Equipment	11,537.64	
Electric Generators	2,490 08	
Accessory Electric Equipment	670 37	
Miscellaneous Eqiipment	81 38	
		$17,812.50
Cost of plant equipment without building		14,779.47

The rated capacity of the gas plant is 160 hp., or about 100 kw. The cost per kilowatt of rated capacity is therefore $178.13, including the building and $147.79 without the building.

The detailed cost of the steam plant was:

Building	$22,001 15	
Boilers, accessories, economizer, stack and flues (stack cost $2,800)	13,653 35	
Main engines	7,219 31	
Electric generators	3,969 90	
Switchboard and auxiliary electric equipment	2,185 18	
Miscellaneous plant equipment	199 71	
General equipment (not specified in the company's accounts)	823 45	
Engineering and superintendance	2,334 97	52,378.32

The rated capacity of this plant is 250 kw. The cost per kilowatt, including the building is therefore $209.51, and $121.50 per kw., not including the building. A comparison of first costs may be made more readily if the figures are arranged as follows:

	Including Building	Not including Building
Cost of gas plant per kilowatt	$178 13	$147.79
Cost of steam plant, per kilowatt	209 51	121.50

The superior character and high cost of the building housing the steam plant constitutes an excessive burden on the operating charges, even though the rate of depreciation charged is only 2 per cent. A building cost of nearly 50 per cent. of the total plant cost seems to the author to be unwarranted, especially as the cost of building materials and labor were not above the average.

The cost figures for the years 1909, 1910 and 1911 were accurately kept up to the time of starting the steam station, which was about the first of October, 1911. The principal items making up the total costs are as follows:

	1909	1910	1911 (Jan. —Oct.)
Station labor	$2,234 18	2,892 88	2,499 94
Fuel	1,097 67	1,611 75	1,356 15
Supplies and expenses	219 91	353.16	299 81
Repairs	587 40	940.30	183.51
Total	4,139 16	$5,798 09	$4,339 41

A distribution of the repair account should be instructive and is as follows:

	1909	1910	1911 (Jan.— Oct.)
Building	$ 31 06	$128 33	$46 53
Gas power equipment	512 66	561 31	136 98
Electric equipment	22 86	147 97	
Water supply		20.68	...
Miscellaneous	20 82	82 01	...
Total	8587 40	8940 30	$183 51

It is possible that one reason for changing to steam power is shown in the cost of repairs to the gas-power equipment.

The amount of power developed in the gas-power station was ascertained from the daily log in which the power was entered for each half hour of the day. No recording wattmeter was used in this station. During the year 1910, the total load for the year amounted to 176,660 kw.-hr. The daily load was distributed approximately as follows: An average of 11 kw. for a period of 10 hr., an average of 15.2 kw. for 10 hr., and an average of 55 kw. for 4 hr., with a maximum of about 75 kw. for about 1 hr. The loading factor was very small, slightly over 20 per cent.

The cost per kilowatt-hour, not including fixed charges, for the year 1910 was $5798.09 ÷ 176,660 = 3.28c. Of the items constituting the operating expense, station labor constitutes 50 per cent., fuel 28 per cent., supplies, 6 per cent., and repairs about 16 per cent. of the total. The repairs to the gas machinery during this period amount to nearly 4.9 per cent. of the first cost.

The fixed charges are calculated on the following assumed percentages of the first cost: Depreciation on building, 2 per cent., on all machinery in the building, 5 per cent.; interest on investment, 5 per cent.; taxes and insurance, 3 per cent. On these percentages the yearly amounts are:

Depreciation, building	$ 60 66
Depreciation, machinery	738.97
Interest on investment	890 63
Taxes and insurance	531 37
Total	$2,221 63

Total Operating Cost of Gas Plant

The total operating cost of the gas plant for the year 1910 is the sum of $5798.09 and $2224.63, or $8,022.72. The total cost per kilowatt-hour is therefore nearly 4.54c.

For the year ending Dec. 31, 1912, the cost of operating the steam plant was as follows:

Station superintendance and labor	$3,614 64
Fuel	4,126 95
Supplies and expense	570 87
Repairs of building	114 02
Repairs of steam equipment	54 20
Repairs of electric equipment	13 84
Repairs, miscellaneous	21 57
Total	$8,546.10

These itemized expenses are very nearly the following percentages of the total expense: Superintendence and labor, 42 per cent.; fuel, 48 per cent.; supplies and expenses, 6.7 per cent.; repairs to building, 1.3 per cent.; repairs to steam equipment, 0.63 per cent.; repairs to electric equipment, 0.51 per cent., and miscellaneous repairs, 0.36 per cent.

The amount of power developed in the steam plant during the year 1912, as measured by the recording wattmeter, was 263,150 kw.-hr. The load factor for the entire year was higher than that of the gas plant, being nearly 29 per cent. The maximum load came in November and December and was about 115 kw.

The operating cost per kilowatt of power developed was therefore 8546.10 ÷ 263,150 = 3.25c. per kw.-hr.

The fixed charges against the steam plant are calculated on the same percentages as those on the gas plant, except for a known charge for boiler insurance which does not affect the propriety of the percentages for taxes and insurance. The amounts of the fixed charges for the steam station therefore become as follows:

Depreciation, building	$ 440 02
Depreciation, machinery	1,518.85
Interest on investment	2,618.91
Taxes and insurance	1,571.35
Total	$6,149 13

Total Operating Cost of Steam Plant

The total operating cost for the steam plant for the year 1912 is therefore the sum of $8546.10 and $6149.13, or $14,695.23. This sum divided by the load in kilowatt-hours (263,150) gives a total cost per kilowatt-hour generated of very nearly 5.6c. Of the total cost of operation, the fixed charges amount to nearly 42 per cent.

In the gas plant, the fixed charges amount to only 27.7 per cent. of the total cost of generation.

It may be noted that no mention has been made of the value of the land in either case. The company owning the lighting system owns a considerable amount of land in the vicinity of the plant, and the value of that on which both the gas and steam plants are situated is so relatively small and so nearly equal in both cases that no appreciable error is made in disregarding it in the calculations.

Comparative data for the two plants will be best shown if arranged in the form of a table and this is done as follows:

	GAS	STEAM
Cost per kilowatt-hour of rated capacity, total	178 13	209.51
Cost per kilowatt-hour of rated capacity, without building	147 79	121 50
Rated capacity of station, kilowatts	100	250
Load factor for year considered	20 percent	29 percent.
Size of anthracite fuel	Pea	No.1 Buckwheat
Price per ton at the plant	3 90	3 50
Total cost of generation, cents per kilowatt-hour	4 54	5 6
Cost of generation, without fixed charges	3 28	3.25
Percentage of generating to total cost	72.3 percent.	58 percent.

It is the opinion of the author that some of the figures shown depart from what may be considered average practice, and these abnormal conditions have considerable influence on the cost of generation. The large amount of unburnt fuel and the excessive repair charges in the gas plant undoubtedly make the generation cost of 3.28c. higher than the average.

The high fixed charges against the expensive building of the steam plant makes the operating cost excessive.

The fairer basis of comparison is perhaps the cost of generation without the inclusion of fixed charges. The figures of 3.25c. for for the steam station might be considered very fair for the conditions of operation, while the figure of 3.28c. for the gas station is, in the writer's opinion, higher than could have been obtained by better operation which was easily possible.

Lignite as a Fuel for Gas Producers

By G. W. Muench

As a fuel lignite is inferior to the higher grades of coal, being less distantly removed from woody fiber, and containing more hydrogen and usually considerable water. Much of the latter, however, dries out on exposure to the air. In some cases as much as 40 or 50 per cent. of water is found in the freshly mined lignite, of which at times 20 per cent. remains when air dried. This greatly affects its value as a fuel.

The amount of ash varies greatly, in some cases being as low as 0.9 per cent. and in others as high as 58 per cent. In burning lignite under boilers there is considerable loss in the waste gases on account of the quantity of air introduced and the moisture carried off.

Although unsatisfactory under boilers, it can be handled very successfully in a gas producer. In the Pacific Northwest producers are operating on lignite having a

heat value as low as 7500 B.t.u. per lb. as fired and seldom higher than 9500 B.t.u.

All lignites contain a high percentage of volatile matter, and, therefore, a large amount of tar, which has been a hard proposition to overcome successfully, to prevent the clogging of pipes and valves and to keep it out of the engine cylinders. However, there are now many gas washers which clean the gas thoroughly. Many types of centrifugal washers have been invented, and the most successful of these wash the gas so thoroughly and allow so little tar to pass through with the gas that an extremely small quantity reaches the engine cylinders. To be fit for use in an engine the gas should not contain more than 0.0205 gr. per cu.ft. This degree of purity is obtained without much trouble, providing the producer is properly handled. Regardless of the type of power plant, one must always count on reliable engineers and firemen.

Some lignites cause trouble on account of clinkers. However, skillful handling of the fire and the proper amount of steam will overcome this trouble with the average lignite. It is practically impossible to tell from the proximate analysis whether or not a coal clinkers. In the writer's experience the best way to test a coal for clinkering properties is as follows: Take a piece of 8- or 10-in. pipe about 2 or 3 ft. long; place this over a forge blast, fill it with the coal to be tested; turn on the blast slowly and allow it to burn, and keep conditions as near as possible to the working conditions of a producer. If the fuel has a tendency to clinker badly the whole mass will form solid in the pipe. This method is rather crude, but nevertheless gives a fair idea of what may be expected when used in a producer.

The writer has not only analyzed in the laboratory a great many samples of lignite, but has also tried out many in producers in actual operation and obtained analyses of the resulting gases. The following analyses were not made with special reference to the quality of the lignites for various purposes, but only as to whether they could be used in a producer satisfactorily. In all cases the plant was operated by the regular crew and under normal operating conditions. The 300-hp. suction producer of the up-draft type furnished gas for a 250-hp. Muenzel gas engine. The washing apparatus consisted of a tower scrubber, dry scrubber and centrifugal tar extractor. The engine load consisted of a refrigerating machine and a generator, and was rather variable. Table 1 gives the analyses of lignites actually used.

TABLE 1

	1	2	3	4	5	6	7	8
Moisture	19.0	17.8	11.6	9.7	22.0	7.7	8.2	20.8
Volatile matter	31.3	29.7	37.5	24.9	24.8	53.5	44.6	32.8
Fixed carbon	35.8	32.0	36.6	36.2	27.8	20.5	30.0	32.1
Sulphur	1.7	1.8	0.6	0.4	0.5	0.4	0.4	1.4
Ash	12.2	18.7	13.7	18.8	24.9	17.9	16.8	12.9
B.t.u. per lb.	10,300	9943	10,925	10,598	8400	8269	10,488	10,177

Remarks: Samples Nos. 1, 2, 5 and 8 were non-coking; No. 4 slightly coking and Nos. 3 and 7 clinkering.

All coal analyses for heat value were made with a Parr calorimeter, and in all cases four or five samples were analyzed completely and the figures shown are average values. The heat value in all cases is that of the dry coal. All the samples were taken directly from the car and the regular quartering method was used for obtaining a good average sample. All samples were kept in air-tight jars and in most cases the analysis was made the same day the sample was taken.

Table 2 gives the analyses of the gas produced by these lignites. The samples were drawn from the suction line between the dry scrubber and the engine and all analyses were made with a Hempel apparatus. A number of analyses of each sample were made in all cases, and a number of samples were taken at various times; the figures in the table are average values.

TABLE 2

	1	2	3	4	5	6	7	8
Carbon-dioxide	6.8	6.0	7.5	8.9	5.4	4.0	7.0	7.6
Oxygen	2.6	2.2	1.9	2.3	2.6	0.8	3.0	0.4
Hydro-carbons	0.0	0.0	0.3	0.0	0.0	0.0	0.1	0.0
Carbon-monoxide	14.2	12.9	11.6	10.8	14.6	15.8	8.8	14.6
Methane	6.3	6.8	7.0	6.2	8.5	12.7	7.3	6.1
Hydrogen	12.2	8.7	8.6	12.5	13.3	8.0	8.0	10.6
Nitrogen	57.9	63.4	63.1	59.3	55.6	58.7	65.8	60.7
Heat value per cu.ft. B.t.u.	171	150	162	141	182	208	118	152

Samples Nos. 1 and 2 contained a very slight trace of hydrogen-sulphide (H_2S). Sample No. 3 was taken while the producer was clinkering badly. Gas No. 5 contained 0.00528 gr. of tar and dust per cu.ft., and gas No. 6, 0.00385 gr., both of which were well within the safe limit. Other tests for purity were taken occasionally and although some were higher than these figures, none were higher than 0.015 gr. per cu.ft. Such a degree of purity, of course, calls for very efficient gas-washing apparatus and plenty of water. These samples of lignite varied in volatile matter from 24.8 per cent. to 53.5 per cent. This large amount of tar does not mean that it is an absolute loss where no byproduct apparatus is used, for even the raw, tarry matter, if passed through a skimming tank, can be sold without any expense in handling and without any added trouble.

Besides the lignites given in Table 1, samples of other low-grade coals were obtained from various mines. Analyses of these are given in Table 3.

TABLE 3

	9	10	11	12	13
Moisture	5.3	1.8	21.4	5.6	11.2
Volatile matter	44.4	41.3	20.5	44.7	45.7
Fixed carbon	46.9	44.2	14.3	29.7	27.3
Sulphur	0.4	3.2	3.8	0.8	2.0
Ash	3.0	9.5	40.0	19.2	8.2
B.t.u. per lb.	13,013	13,107	6,100	9,928	10,500
Remarks	Coking	Coking			

	14	15	16	17	18
Moisture	24.4	1.2	21.0	23.5	4.7
Volatile matter	35.1	23.1	36.6	32.6	29.6
Fixed carbon	30.3	66.0	34.1	31.7	53.5
Sulphur	2.0	0.7	1.7	1.0	3.1
Ash	8.2	9.0	6.6	11.2	9.1
B.t.u. per lb.	10,500	13,138	10,850	10,850	12,680

Table 3 shows coal varying in moisture from 1.2 to 24.4 per cent. and having ash as high as 40 per cent. with a heat value as low as 6100 B.t.u. per lb. of dry coal.

Of course, there are many coals in the same section of country that are of a very much better grade than those given, but the idea is to show that enormous quantities of extremely low-grade coal exist, nearly all of which are good for gas-producer use.

Pennsylvania Coal Production in 1912—The combined production of anthracite and bituminous coal in Pennsylvania amounted in 1912 to 246,227,086 short tons, valued at $346,993,123, against 235,218,230 tons, valued at $321,537,250, in 1911, according to E. W. Parker, of the United States Geological Survey, who compiled the figures in coöperation with the State Topographic and Geologic Survey Commission. The increase in quantity was 4.7 per cent. and the gain in value 7.9 per cent. The production of bituminous coal in 1912 exceeded that of anthracite by 77,593,890 short tons, or 93 per cent., but the value of the latter exceeded that of the former by $8,252,129.

HEATING AND VENTILATION

Time Required to Start Heating Apparatus*

In figuring the time that is required to warm up or start heating apparatus a proper allowance must first be made for the starting of the fire, or bringing it, if banked, to its normal operating condition. If the water in the boiler is cold, allowance should also be made for the warming of the water and iron in the boiler itself. As boilers are generally covered with a heat-insulating covering, the loss in heat from the outer surface of the boiler is usually small and does not, as a rule, need to be considered separately. If, however, the boiler is not covered with an insulating covering the loss in heat may ordinarily be charged directly against the heat-producing capacity of the boiler.

The question of the heat-producing capacity of the boiler is one which may be figured or which may often more satisfactorily be obtained from the boiler performance curves of the manufacturer. These curves show the steam-producing capacity of the boiler under different conditions of operation, and they are now being furnished by enterprising boiler manufacturers.

From the boiler-performance curves one can determine the steam or B.t.u. which the boiler can properly produce in a given time, say one hour or one minute. The weight of the iron and water in the boiler can also be obtained from the manufacturer or by measurement.

In the case of a cast-iron boiler the weight of the iron in pounds should be multiplied by 0.13, the specific heat of cast iron. The product will be the weight of water to which the iron is equivalent in heat-absorbing capacity. This amount should be added to the weight of water in the boiler and this sum multiplied by the difference in temperature, Fahrenheit, through which the iron and water in the boiler are to be raised. The product will, of course, represent the B.t.u. which must be given to the iron and water before steam is produced. If, therefore, the average heat-producing capacity of the boiler in B.t.u. per unit of time can be determined, the total B.t.u. required to heat the iron and water in the boiler can be divided by the B.t.u. which the boiler will produce in a unit of time and the number of units of time, whether they are minutes or hours, be determined.

After the time required to heat the boiler has been figured the time required to heat the piping and radiation in the heating apparatus itself may be determined. This is a different question from the former and the author, by means of some interesting mathematics, developed a formula for steam-heating apparatus. To illustrate the use of the equation certain examples and curves were worked out and a similar equation for hot-water heating was discussed.

In Fig. 1 each curve represents a condition in which there are certain fixed temperatures in the building at the start and also when the apparatus is completely warmed up. For example, one curve is marked 50-70 deg., F. This means that the building is at a temperature of 50 deg., F., when steam starts to enter the apparatus and that the building is at a temperature of 70 deg., F., when the apparatus is completely warmed. The curves are worked out for a steam temperature of 220 deg., F., and on the basis that each square foot of radiation calls for 7 lb. of cast-iron and gives off 250 B.t.u.

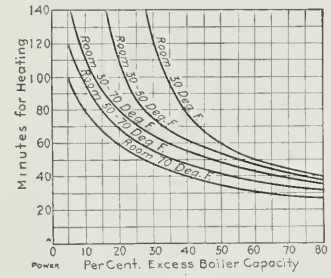


FIG. 1. TIME REQUIRED TO HEAT STEAM RADIATION

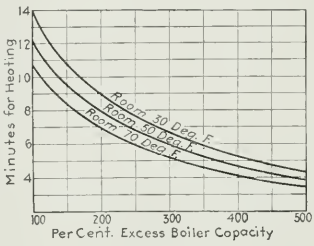


FIG. 2. TIME REQUIRED TO HEAT COVERED STEAM PIPING

(For pipe surface use from ⅝ to ¾ of time shown)

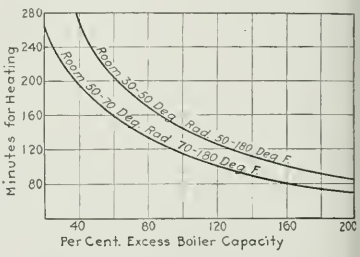


FIG. 3. TIME REQUIRED TO HEAT HOT-WATER RADIATION

In Fig. 2 curves are shown which are similar to those in Fig. 1, except that they are figured for covered piping where the heat loss per square foot of piping is taken as 50 B.t.u. If the piping is covered the time of the heating of the covered pipes can first be determined from the curves in Fig. 2, and it can usually be figured that the total boiler supply is first used in heating the covered pipes. When this is done the heat given off by the covered pipes can be subtracted from the boiler supply and the difference can be used as the steam supply to the uncovered radiation. The time of heating the radiation itself can then be determined from the curves in Fig. 1 and added to the time required for heating the covered piping.

*Abstract of a paper read by Ralph C. Taggart before the American Society of Heating and Ventilating Engineers, July 17-19, Buffalo, N. Y.

In hot-water heating apparatus the heating of the iron and also the water in the boiler should be allowed for. The loss by radiation may then be considered proportional to the amount of heat in the apparatus, if there is at the start some little difference in temperature between the room and the water in the apparatus. If this is not so, the work may be divided into several calculations, the periods being so chosen that during each of them the loss of heat will be approximately proportional to the heating of the apparatus. This means that it will usually be sufficient to divide the calculations into two, or at most three periods, because, although there will be some variation when the difference in temperature between the heating apparatus and the room is small, still, in this case, the heat loss itself is also relatively small, so that the error is proportionately decreased.

The curves in Fig. 3 are similar to those in Fig. 1. They are based on 5 lb. of water per square foot of radiation. It is interesting to notice that, if more radiation is installed and operated at a lower temperature, the same time is required to bring either quantity of hot-water radiation up to a temperature.

The time shown by the curves of Fig. 3 might have to be increased if the pipes are large and so hold much more water per square foot of surface than does ordinary radiation. One and a half or two-inch pipe holds about the same amount of water per square foot of surface as does ordinary radiation. Doubling the diameter of the pipe doubles its surface, but its content is increased four times, so that the water in the pipe per square foot of surface is doubled. The time, however, might only have to be increased, say 50 per cent., because the iron in the piping and the iron and water in the boiler are not increased in this ratio per square foot of surface by the increase in the diameter of the pipe.

Special Venturi Style Elbows*

Besides the tests described in the Aug. 26 issue of POWER, a series of tests on air ducts was also made to determine the effect of reducing the area of an elbow at the throat to the theoretical or equivalent area. The shape assumed by such an elbow is shown in Fig. 1. This special form of elbow was suggested by Konrad Meier, in his book, "Mechanics of Heating and Ventilating," and the idea advanced that by reducing the area to the equivalent orifice, eddy-currents would be prevented along the inner side of the pipe. This would tend to prevent one source of friction, and the long-cone effect would aid in changing the accelerated-velocity pressure at the turn of the elbow back to static pressure with a minimum loss.

Of the total loss of head in rounding an elbow, about 44 per cent. is regained in the straight part of the elbow after making the turn, and the balance, or 56 per cent., is entirely lost. The loss in pressure due to any elbow, as shown by the diagrams presented in the previous article divided by 0.56 gives the total loss at a point just after rounding the turn, or at the point where the theoretical orifice or blast area is to be calculated. By adding 1.0 to this total loss and taking the square root of the reciprocal, the theoretical area as a percentage of the actual area is found.

As an example of this calculation, assume an elbow in a 12x12-in. duct, the elbow to have a center-line radius of ½ *W*. According to Fig. 4, in the first article, the loss in this elbow will be 0.95 of a velocity head, and the loss at the point of equivalent orifice will be

$$0.95 \div 0.56 = 1.6 \text{ velocity}$$

Then the blast area will be

$$\sqrt{\frac{1}{1.6 + 1.0}} = 0.62 \text{ of the present area}$$

The foregoing represents an extreme case, and it seems safe to assume that for ordinary square-turn elbows the theoretical area is two-thirds of the actual area. That

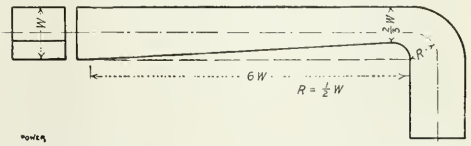


FIG. 1. SPECIAL VENTURI-STYLE ELBOW USED IN TESTS

is, with a 12x12-in. elbow the width to two-thirds of the normal size without interfering with the air flow or causing an increase in velocity due to the restriction. The greater the center-line radius of the elbow considered, the less will be the loss of pressure through the elbow and the more nearly the theoretical area will approach to the actual. Thus with an elbow having a center-line radius of 1½ *D* the theoretical area would be 94 per cent. of the actual.

To study the effect of reducing the throat of an elbow as just described, special venturi-shaped elbows were designed on the foregoing basis, and their effect ascertained in the same manner as had been already done in the case of ordinary elbows. The results of these tests are here given, and the accompanying sketches will aid in understanding the arrangements of elbows used.

Case I—A standard elbow having $R = \frac{1}{2} W$ was attached to the outlet of the test box and a 6-ft. length of pipe added to give the same length as used in making the special elbow. As indicated on the sketch, the loss due to the elbow and 6 ft. of pipe was 94 per cent. of the velocity head.

Case II—The standard elbow was replaced by the special venturi-shaped elbow, and the same conditions as to air pressure maintained. The loss now was 37 per cent. of the velocity head, showing a saving of 57 per cent. of a velocity head, or 60.7 per cent. of the loss indicated for the standard elbow.

Case III—An offset of 1¼ times the width of the pipe was arranged and two short-bend standard elbows used. The total loss from *A* to *D* was found to be 219 per cent. of the velocity head.

Case IV—The second elbow was replaced at *B* with the special elbow and the loss found to be 98 per cent. of a velocity head. The saving due to the use of the special elbow is seen to be 121 per cent. of a velocity head, or 55.4 per cent. of the original loss.

Case V—An offset of four times the pipe width was arranged with the two short-bend standard elbows, and the loss from *A* to *C* found to be 161.5 per cent. of a velocity head. The saving over Case III due to the greater offset was 21.6 per cent., but the arrangement

*From a paper read by Frank L. Busey before the American Society of Heating and Ventilating Engineers, July 17-19, Buffalo, N. Y.

shown in Case IV, where one special elbow was used, showed a saving over Case V of 44 per cent.

Case VI—Two easy, long-radius elbows were arranged as shown, to determine the saving due to these elbows as compared with the ones used in Case V. This arrangement gave a saving of 79.2 per cent. of the loss indicated for Case V.

Case VII—The same elbows were used as in Case VI, and a short length of pipe inserted between the elbows, increasing the offset from 2½ to 5½ times the pipe width. For some unaccountable reason the loss indicated was greater than for Case VI. It is possible that this arrangement is more productive of eddy currents in the second elbow than the arrangement of Case VI.

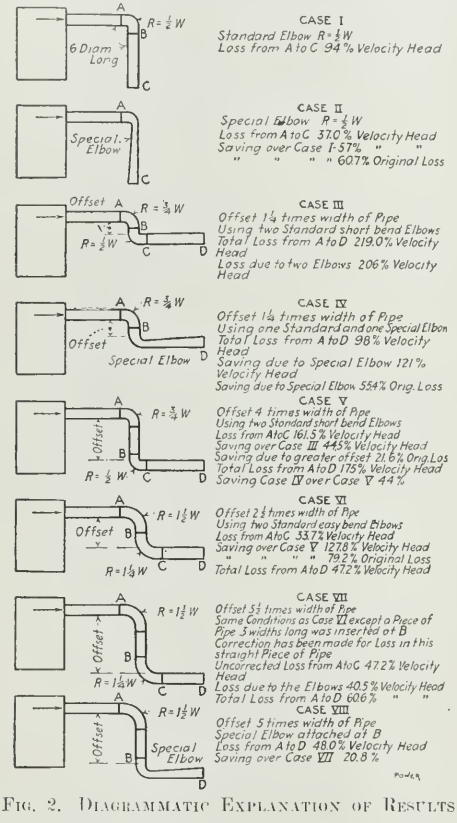

CASE I
Standard Elbow R = ½ W
Loss from A to C 94% Velocity Head
6 Diam Long
CASE II
Special Elbow R = ½ W
Loss from A to C 37.0% Velocity Head
Saving over Case I 57% " "
" " " " 60.7% Original Loss
Special Elbow
CASE III
Offset 1¼ times width of Pipe
Using two Standard short bend Elbows
Total Loss from A to D 219.0% Velocity Head
Loss due to two Elbows 206% Velocity Head
Offset
CASE IV
Offset 1¼ times width of Pipe
Using one Standard and one Special Elbow
Total Loss from A to D 98% Velocity Head
Saving due to Special Elbow 121% Velocity Head
Saving due to Special Elbow 55.4% Orig. Loss
Special Elbow
CASE V
Offset 4 times width of Pipe
Using two Standard short bend Elbows
Loss from A to C 161.5% Velocity Head
Saving over Case III 44.5% Velocity Head
Saving due to greater offset 21.6% Orig. Los
Total Loss from A to D 175% Velocity Head
Saving Case IV over Case V 44%
CASE VI
Offset 2½ times width of Pipe
Using two Standard easy bend Elbows
Loss from A to C 33.7% Velocity Head
Saving over Case V 127.8% Velocity Head
" " " " 79.2% Original Loss
Total Loss from A to D 47.2% Velocity Head
CASE VII
Offset 5½ times width of Pipe
Same Conditions as Case VI except a Piece of Pipe 3 widths long was inserted at B
Correction has been made for Loss in this straight Piece of Pipe
Uncorrected Loss from A to C 47.2% Velocity Head
Loss due to the Elbows 40.5% Velocity Head
Total Loss from A to D 606% " "
CASE VIII
Offset 5 times width of Pipe
Special Elbow attached at B
Loss from A to D 48.0% Velocity Head
Saving over Case VII 20.8%
Special Elbow
POWER

FIG. 2. DIAGRAMMATIC EXPLANATION OF RESULTS

Case VIII—The same arrangement as used in Case VII, except the second elbow was replaced with the special elbow. As indicated, a saving of 20.7 per cent. over Case VII was obtained.

As may be noted from the data given, the principal gain due to the special elbow is when it is used to replace a short-bend standard elbow in which the loss of pressure is excessive. Special elbows were also tried with a center-line radius of 1½ W, but, as might be expected, the gain was not sufficiently great to warrant the extra expense of construction.

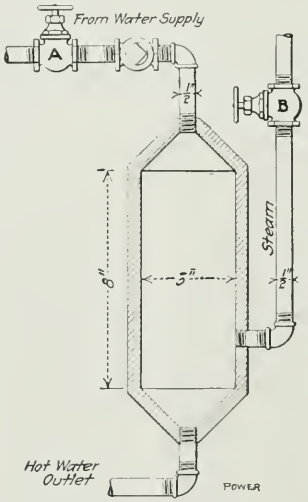
The special elbow might be used to advantage in either of two cases. First, where a horizontal run enters a riser at such close quarters that an easy elbow is out of the question and a sharp-bend elbow with center-line radius of ½ W must be used. Second, where a close offset must be made, as might be required in passing around an obstruction or through a wall. If the offset is sufficiently great to permit the use of long-radius, easy-bend elbows it is questionable whether it would be worth while to use the special elbow. The loss due to the easy standard elbows would be so slight that the saving due to the special elbow would be insignificant.

According to the test results the saving due to the use of the special elbow, as in Case II, resulted in a saving of 0.57 of a velocity head as compared with a short-bend elbow. When used to replace the second elbow in an offset, as shown in Case IV, the saving was 1.21 of a velocity head. In either event the saving was from 55 to 60 per cent. of the original loss.

❖

A Heater Trouble

I have the care of an Economy hot-water heater that was installed about three years ago. This heater consists of a cast-iron body 8 in. long and 3 in. in diameter with a ½-in. water inlet at the top, a hot-water outlet at the bottom and a ½-in. steam inlet on the side. To operate the heater, open valve *A* and then valve *B*. The two valves are adjusted to get the temperature desired. In the water supply there is a check valve to prevent an unequal steam pressure from forcing the water back into the supply pipe. There should also be one in the steam-supply pipe to prevent the water getting into it.



SECTION THROUGH HEATER

This heater is used when only a small amount of water is desired at one time. It heats the water all right, but it has a fault that I would like to remedy. The steam in coming in direct contact with the water causes a slight water-hammer which stirs up the sediment that has settled in the pipes and heater and causes the water to be slightly colored. If any reader has had experience with this type of heater, I should be glad to learn of a remedy for the trouble without renewing the piping.

L. N. WEBSTER.

Springfield, Mass.

EDITORIALS

Central Power Station Rates

In response to a request from the Uniform Electric-Rate Association, Louis D. Brandeis has delivered an opinion that:

Assuming that the cost of producing and delivering electrical energy is the same per unit, regardless of the quantity supplied, and in the absence of any statute regulating or limiting the price at which it may be sold, a public-service corporation cannot legally charge a lower rate for a larger than for a smaller quantity delivered at the same time and under similar conditions.

Assuming that there is a difference between the cost of making, delivering and selling electrical energy as between the wholesale and the retail consumer, a public-service corporation can, in the absence of any statute regulating or limiting the price at which it shall be sold, make a higher price to the retail customer, but the difference in selling price may not be substantially greater than the difference in cost.

Upon the case which to the lay mind would seem to offer no possible excuse for difference in rate, namely, the use to which the current is to be put, Mr. Brandeis says there is more doubt. It costs an electric company a certain (or uncertain) amount to produce current, upon which cost it is entitled to make a fair profit, and it is hard to see what difference it makes whether the customer uses the current for light or heat or power or metallurgical purposes, or electroplating or whatever else he chooses. If his work requires more of it than would some other use, it is the question of quantity, disposed of in the above-quoted opinions. If it is because the current for the specified purposes is required at off-peak times, when the plant would be otherwise underloaded, it is a question not of use or purpose but of time of service. Under no circumstances could the mere use or purpose for which the current is bought appear to justify a difference in rate or to be of any concern to the selling company.

Mr. Brandeis says that "some decisions in the state courts would seem to justify such discrimination, but the great weight of authority as well as of reason seems opposed to permitting any discrimination based upon the use to which electric energy is put; and therefore, upon the facts assumed in the question, such discrimination between charges for electrical energy used for power and charges for the electrical energy used for light should be held illegal."

"On the other hand, the difference between day use—when the demand upon the station is small—and evening use—when the demand upon the station is large—seems a proper basis of classification of service; and a court might, for this reason, upon the facts disclosed in a particular case, hold that use for power as calling mainly for day use, fell within a different class of service than use for light."

Here again it is admittedly a question of time and not of purpose, and the confining the use to power purposes does not necessarily keep the demand off the peak, although it extends the demand over the period of light load and increases the power factor.

A plant designed primarily for furnishing electric light, having only a night load and selling current at a price which pays a profit upon the total cost of production, including all the standing charges, could afford to sell current at a very low price during the day time. The extra cost of producing that current would be very small and it could be sold at a price with which the isolated plant could not compete unless it had use for a large proportion of its exhaust steam. The result would be that the day user would get his current cheaper than he could make it, the electric company would make money, and the night user would pay no more, although he would not share in the improved efficiency of larger use of the plant.

In making up the "difference in cost" of different services upon which a difference in rates may be allowable in the second opinion above quoted, is the day or power load to be allowed to escape all overhead charges, or all except those which are directly occasioned by its taking on, or is it to be made to bear its proportion of the whole of them?

What would be the case if the power or day load were the principal part of the business, if a plant were put down primarily to run a group of mills and factories. Would they charge all the overhead expenses in making up the cost which should establish the day rate and then sell the current for lighting at night at a fair profit on its *additional* cost?

If the standing charges are to be equally distributed over the production, i.e., the charge per unit determined by dividing the total standing charge by the number of units produced, the average cost will be above that at which current can be sold in competition with an isolated plant of any considerable size. And this leads to a most pertinent and important point in the opinion, not brought out in answer to any direct inquiry, but coming in incidentally, and that is to the effect that a public-service corporation cannot discriminate in rates, because it cannot get the business otherwise; that it is not justified in cutting rates to meet competition unless it cuts them to everybody.

We shall be interested to see what view the courts take of the question, if, as we understand it, the intention of the association is to bring some test cases to trial.

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Appreciation of the Engineer

More and more as men are graduated from engineering schools, the profession of engineering, in its various divisions, is coming to rank with law, medicine and the other professions, both as to dignity of occupation and enjoyment of protection. The time has passed when buying a transit makes the purchaser a civil engineer,

or stringing a wire to light his kitchen makes a man an electrical engineer.

So much for the technical fellows, and we hear the vast number of good, practical men call "More power to their arms." Each year shows closer coöperation between the young fellow with his degree and the man with his years of practical experience. The old feeling of animosity is being replaced by a spirit of exchange of knowledge which works for the betterment of both men.

Today, we find in the larger plants a man who is known as the chief engineer. In his department and under his direction are to be found assistant engineers, oilers, firemen, etc. Here the engineer is looked upon by the management as a man who shoulders a vast amount of responsibility and upon whose efficiency depends the plant production, to a large degree. Other plants, although smaller, are fully as important when proportion of operating expense to output is considered. Here we probably find one man acting as chief engineer, assistant engineer, oiler and fireman, but the consideration he receives seems to be inversely proportional to the diversity of his duties.

Not infrequently a department foreman not only enjoys closer coöperation with the management, but is rewarded more generously for his services, than is the man at the head of the power department.

Consider a few of the responsibilities of both positions. The foreman must look to the welfare of the employees working in his department. In case of accident, he signals to have the machines stopped, and production in his division is retarded for a short time. The engineer is responsible for the life of every person in his building, and, in closely settled districts, the people in the adjoining buildings. The engineer must not have accidents—it is part of his duty to see that they do not happen.

How much intelligence a foreman must have to hold his position, is indefinite, but a glance at the requirements for an engineer's license is convincing that the framed document in the engine room stands for head work as well as hand work.

There is one man, however, who defers to the engineer—the purchasing agent. He may be able to select the department material as well as the foreman, but when the article happens to be a sample of packing, a new type of blowoff valve, a solution of the boiler-scale problem, etc., the representative is generally told to "just step back to the rear and talk to the engineer; he is the man who knows about these things."

Much is being accomplished by the splendid organizations of engineers which are to be found in most towns and cities. For one thing, they place a limit to the time that the engineer may be away from his engine room. This alone has done away with such unpleasantnesses as the following:

A first-class engineer in a plant, who also acted as fireman, millwright, master-mechanic and general trouble-man, was found by his employer reading his technical paper. The employer hurried out of the engine room, but returned in a few moments and ordered the engineer to lay down his paper, and come with him to the lawn in front of the office, where he could spend his time to better advantage in digging the weeds out of the grass. This employer was surprised to learn that his engineer was limited to 15 minutes absence from his engine room.

Such employers fortunately are of the old school and fast disappearing. The new generation in control is largely made up of graduates of technical schools, and these men realize and foster a closer bond between themselves and their engineer. Each year shows more attention being given to the vital point of the plant—the power house, and with this is to be expected an increased consideration, on the part of the management, for the engineer.

Plant Repairs during the Slack Season

In the late summer many industries have their slack season, and frequently the plant is shut down for a week or so. At these times the engineer has a chance to do considerable repair work. Perhaps no time would be better to make readjustments of operating conditions, not only in the power plant, but through the various departments that go to make for the finished output. Possibly the engineer has felt for the past six months that the friction load was excessive. A careful inspection of shafting, noting alignment, condition of bearings, hangers, etc., may often make a considerable reduction in the friction load.

There is always the repacking and truing up of the various units, and the piping will need some attention, but while working with the piping it may be possible to make some changes, which together with the proper pipe covering, will show a saving for the boiler feedwater heater or the exhaust-steam heating system. If an air compressor be among the equipment it may be possible to reduce the leakage.

When the main unit drives a generator, it is well to have the switchboard instruments corrected. This may mean either sending the instruments back to the makers, or if time will not permit of this, it would be well to have comparisons made with standard instruments.

Throughout the plant where motors are used it may be possible to improve conditions of load. By placing the motor nearer the center of load, that is, having the load more evenly distributed along the line shaft, to both sides of the motor, an improvement may be effected.

Many modern machines are supposed to be operated at high speeds. With proper selection of speed of motor, size of motor pulley and line-shaft pulley, the correct operating speeds for the machines can be attained. This will prove to be a more efficient condition for the machine, and with more nearly rated loading of the motor, a more efficient motor operation will also result. A saving of power will follow, which is the engineer's aim.

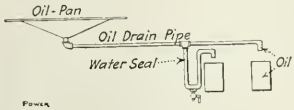
Other things could be mentioned, but the important point is that just at present, when so much is being said about efficiency engineering, the wide-awake engineer is eager to make any reasonable change in his equipment or load conditions that will result in a saving in power costs. It often happens that it is hard for an engineer to get the concern to purchase much new equipment for the power plant, not realizing that such expenditures are investments. For this reason it is necessary for many engineers to make the best possible use of the equipment at hand. Hence, the slack season of summer may be the busy one for the engineer with pet schemes to work out.

READERS WITH SOMETHING TO SAY

Three Useful Kinks

In many plants the installation of economy devices is not always justifiable. For instance, in the plant where the writer is employed there are two self-oiling engines and one which is oiled by hand. An oiling system might be employed on the one unit, but as it operates only six hours each day it is a question whether it would pay for itself by the time it had depreciated beyond usefulness.

The crank of the engine in question is oiled from a reservoir of about one gallon capacity, which is attached to the frame in such a manner that the oil can flow to the crank bearing by gravity. After leaving the bearing the oil falls to the oil-pan in the lower part of the engine frame and from there is drawn into a suitable vessel and again returned to the reservoir to be used over again. The engine being vertical, considerable water leaks into the oil-pan and mixes with the oil. This water



OIL-WATER SEPARATOR

must be separated from the oil before it can be returned to the reservoir for use. This used to be done by drawing the water from the bottom of the oil reservoir, but no matter how carefully this was attended to some water always found its way to the crank bearing, which did the latter more harm than good, necessitating frequent adjustment. I hit upon the scheme shown in the sketch, which is self-explanatory. Since the application of this simple device the crank-bearing has been running without adjustment, and the prospect is that it will do so for some time to come. The material used is of small consequence and the relief from worry and saving of wear fully justifies the time and material put into the job.

On the same engine there is a Rites governor. The eccentric is on one side of the flywheel and the weight-arm on the other. The eccentric-pin bearing had a tendency to wear oblong near the weight-arm due to the alternate direction of the force required to move the valve. This action was further aggravated by a slight wobbling of the flywheel. To overcome this trouble one end of a spring was attached to the center of the governor pin and the other end to the rim of the flywheel in such a position that it counteracted the to and fro movement of the governor-pin in its bearing and held it in line. A little experimenting had to be done before the correct position of the spring and the proper tension was found. The regulation is now entirely satisfactory. The spring used was an old automobile spring and did not cost anything, but its application saved the cost of fitting new bearings and the regulation is better than ever before.

Sometimes a lubricator feed-glass is encountered which gives a good deal of trouble by becoming dirty, thus causing the oil to flow along the side of the glass in a stream instead of rising in drops. It was found that a fine wire placed in a vertical position exactly in the center of the feed-glass would overcome the trouble and also prevent the bursting of the feed-glass from unequal expansion. The method of fastening the wire is immaterial as long as the flow of the oil is not obstructed. The writer uses a piece of 50- or 75-amp. fuse bent into a circle of the same diameter as the feed-glass. To this ring the fine wire is attached so that it is exactly central at right angles to the diameter of the ring. The wire is then cut to a length which will permit the end to enter the feed nozzle from $\frac{1}{16}$ to $\frac{1}{8}$ in., when the ring rests upon the upper end of the feed-glass. This scheme may not work very well in case the lubricator is required to feed very rapidly, with a very heavy oil.

LOUIS T. WATRY.

Pueblo, Colo.

Why Did Trap Fail to Drain Dry Cans?

In our plant there are a number of dry cans on which the cloth is dried before being calendered. Up to about three months ago the condensation from these cans returned by gravity to a receiver situated about 30 ft. from the dryers and 22 in. lower. A pump, governed by a float in the receiver, pumped the water into an open heater, a rise of 28 in.

The pressure in the cans ranged from 6 to 12 lb. The heater pressure is never higher than 1 lb. and oftener it is a partial vacuum. With these conditions we saw no reason why a trap placed near the receiver and loop would not do the work of both and effect a saving. A trap salesman agreed to put a trap in with the understanding that if it did not drain the cans his company would take it out, with no charges for the installation. The trap was installed and our troubles began, but there was no fault with the trap. All the water which came to it was discharged into the heater, but for some reason, which is not clear to me, only a part of the water flowed to the trap, and the cans would not dry. We thought the pipes were air bound, and put in air-relief cocks, but the cans were continually full of water.

Our puzzle was and is, why the water should not flow as freely to a trap as to the pump receiver. We finally set the trap directly beside the cans, which then operated free of water, the trap doing its work satisfactorily. The question is, Why did it not work satisfactorily when first installed?

L. JOHNSON.

Exeter, N. H.

The Independent Plant

Many of the recently published descriptions of independent plants, as well as some of the arguments, pro and con, have been interesting. They reflect, in small measure, the widespread nature of the question. The writer has always contended that with properly adapted, first-class apparatus, almost any plant could, and many do, show superior over-all results to central-station service. In Northern cities the requirement of heating is of decided advantage, and without this credit, the case would be far more difficult.

From this it is an easy step to "block plants," supplying current and heat within their limits, and being real central plants. Moreover, the modern Corliss-valve direct-connected engine, with its flat steam-consumption line, and the natural-draft cooling tower and condenser make an ideal combination. For summer service, such a plant may run condensing, with minimum cost, and practically on an equality with the central station, so far as cost of current at the switchboard, in each case, is concerned. In winter, all the exhaust steam should be utilized, at attractive return.

Again, an existing high-speed installation, perhaps of poor efficiency, can be improved by the addition of a small low-pressure turbine, augmenting and improving the total economy to a remarkable extent. These results were not possible a few years ago, before the development of the four-valve engine, the small turbine, and correct low-cost condensing and water-cooling apparatus.

Or a heating system, either steam or water, can be so connected in between the engine and condenser as to use a large part of the heat generated by the boiler.

Take, as a case, the present high-speed Corliss-valve direct-connected engine, with an initial cost of about $40 per kw. and a steam consumption of not more than 35 lb. per kw.hr., noncondensing, and 27 lb. condensing, the total cost per kw.hr. on a yearly output of, say, 250,000 kw. hours and $4 coal, would not be much over 1¼ cents, all charges included, and no credit for heating. For five to eight months during the year 75 per cent. of the exhaust steam is absorbed by the heating requirements, which would reduce the net cost to about 1 cent, a rate which the central company, with its heavy overhead expense, could not meet, and remain in business.

Better yet, take the very flexible plan of several high-speed units exhausting to a receiver from which a mixed-pressure turbine and a heating system is fed, with connections so arranged that any combination of the units could be secured, the cost would be still further reduced, and the plant become a very profitable investment to the owners and a source of economy and satisfaction to its patrons. These turbines range about $30 per kw. for small sizes, with condensing apparatus about $7.50 per kw., and the power so developed is almost a net gain.

It is usually with old, poorly apportioned machinery, badly operated, in depreciated condition, without complete and authentic records of cost, that the central stations can make a showing on a strictly engineering basis. Granted, that if a new boiler plant is necessary, requiring expensive changes in buildings and occupying valuable space, if the engines are run down and the repair bills high, with frequent exasperating shutdowns, labor troubles, etc., there is little argument.

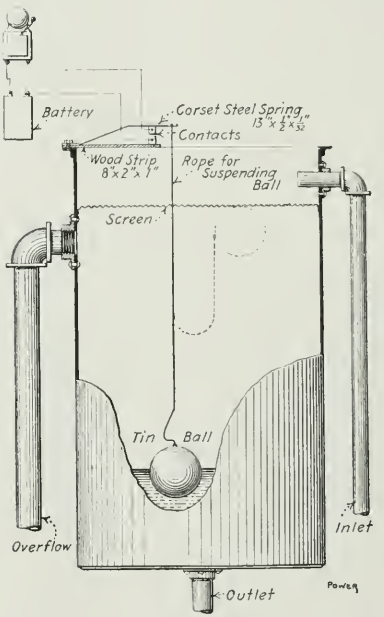
Unfortunately there are many such plants. But in comparing results from a modern well equipped central station it is manifestly unfair to take the independent plant in any but the same condition. Each case is a problem in itself, deserving of careful study by a trained, unbiased judgment, and the result is almost a certainty when so handled. The independent modern plant has nothing to fear if given fair consideration. But this implies an intelligent, well read engineer, up to date on the developments of recent years, and with accurate records of his plant condition and costs.

W. G. STARKWEATHER.

Boston, Mass.

Alarm for Oiling System

The need for an alarm device on oil-tank service is this: All practical men know that the oiler has other things to attend to beside oiling. It is generally the case that something will happen to the oiling system when he is wiping up a machine or polishing bright work. The filter tank is usually in the basement and out of sight most of the time. The gravity tank is elevated in or above the engine room, and the chances are that the oil level in the gage-glasses of this tank cannot be seen unless one gets back in some corner to look at it. The screen gets dirty and the oil will go on the floor, either at the upper tank or the lower one, and one does not know that the basement tank has overflown until it is too late to prevent damage or loss of oil.



ALARM FOR OILING SYSTEM

The supply pump will slow down and all the oil will go to the lower tank and remain there. By equipping the tanks with the device shown all such trouble may be avoided. The illustration is self-explanatory.

Dallas, Tex. JOHN BUTERA.

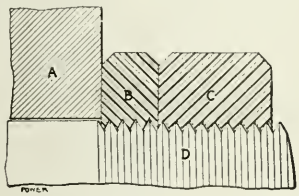
QUESTIONS BEFORE THE HOUSE

Jam Nuts

In "Inquiries of General Interest," June 24 issue, in the answer to the inquiry on "jam nuts," the answer was that the thick nut should be put on first, for, having more threads, it can be drawn up tighter with less danger of stripping the threads, and on account of its greater thickness it can be more easily held by a wrench while the outside nut is turned.

A locknut is usually about one-half as thick as the ordinary nut and for the simple reason that a wrench is generally thicker than this, the nut is placed on the outside for convenience. I am of the opinion, however, that the small nut should be placed next the piece that is being bolted.

Referring to the sectional view, we may imagine a very small clearance between the threads of a nut and the threaded part of the bolt *D*. Then a single nut, when it is tightened against the piece being bolted, will appear as *C* in the figure, the clearance between threads being on



JAM NUT PLACED INSIDE

the right-hand side in this case. In applying the locknut as at *B* it is first tightened against the piece *A* and the nut *C* is then tightened on the top of *B*. The locknut then is tightened back on *C*, the outer nut being held firmly with a wrench, this action grinding the surfaces of the two nuts together; or by holding nut *B* and tightening *C*, we have the same effect without loosening the hold of the bolt. The clearance of the small nut is on the left as indicated in the figure. It will be seen that the large nut not only resists the pull indicated by the contact, but also the load applied by the small nut when it is turned back.

To avoid mistakes a compromise may be made by having both nuts of the same thickness and equal to about three-fourths the thickness of the ordinary nut or where appearance is not a great consideration, two nuts of usual thickness can be used.

CHARLES JABLOW.

Stillwater, Okla.

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[In most situations where a gain or lock nut is employed it is both necessary to obtain the maximum draft before setting the jam nut and to retain the position of the inside nut without backing it against the outside nut. The inside nut must, therefore, be the main nut and the outside nut the jam or lock nut.—ED.]

Says Graphite Is Successful

The letter by E. C. Sutton, of the Esterville (Iowa) Light and Power Co., printed in the Aug. 19 issue, under the heading "Had No Success with Graphite," was read with interest. My experience with graphite has been very different.

Some months ago my advice was solicited by the management of the Castle Heights Water Co., of North White Plains, N. Y., as to a remedy for removing and preventing scale incrustation in the boilers of this company.

I examined the boilers, which were of the horizontal tubular type, and found that there was an average scale incrustation approximating ½ in. in thickness deposited over the interior of the boiler shell and tubes. The feed water used at this plant is not unlike the water of the Croton Watershed, showing an average alkalinity of about 34 parts per million; a permanent hardness of 5 parts, making a total average hardness of about 39 parts per million.

There being two boilers at the plant of 150 rated horsepower, either of which is capable of operating the plant, it was found convenient to try a scale-removing substance upon the heavily incrusted boiler, which at the time of the test was in reserve.

I decided to try graphite on the reserve boiler, known as No. 2. On May 8, I ordered No. 2 boiler placed in operation, at the same time instructing the engineer to feed the graphite to the boiler, through a receptacle tapped and connected to the feed line, on the suction side of the feed pump, and to feed 3 lb. of graphite each day for the first three days and to blow down at the end of the third day. After the third day the quantity of graphite fed was reduced to 1 lb. per day and the boiler blown down every second day until opening up, my intention being to run the test for at least 30 days before shutting down.

On May 25, after 17 days' run, I unexpectedly was compelled to shut down for insurance inspection, and was indeed much disappointed to have to do so as I imagined the graphite did not have sufficient opportunity to demonstrate its scale-removing qualities. My disappointment was more than compensated for, to find upon examination, that the interior of the boiler and the tubes had become practically cleared of scale. Further examination through the rear handhole opening showed that quantities of the carbonates of lime and magnesia mingled with graphite had been precipitated in a sludge consistency easily removable by blowing out.

I am now running a test to determine the worth of graphite as a scale preventive and expect to have the same success, and indeed I am very optimistic of the result as the boiler continues to show increased steaming qualities with a minimum coal consumption.

DANIEL I. CURTIN.

New York City.

Pitting of Boilers Due to Furnace

Under this heading E. Herzog, of Chicago, stated in the July 15 issue, first: "The pitting of boilers in Chicago seems to be quite characteristic to boilers having the dutch-oven type of furnace." Second: "The object of installing this type of furnace is to eliminate smoke, which it does after the furnace gets hot." Third: "This action does not occur in other boilers that use distilled water, but have not that kind of a furnace."

A Chicago ordinance provides for smoke inspection and abatement in the City of Chicago. Sections 14, 15 and 16 read as follows:

Section 14: No new plants or any reconstruction of any old plants for producing power and heat, or either of them, or any new chimney connected with a steam plant shall be erected or maintained in the city until plans and specifications of the same have been filed in the office of and approved by the smoke inspector and a permit issued by him for such erection, reconstruction or maintenance. Plans and specifications to be filed with the smoke inspector shall show the amount of work and the amount of heating to be done by such plant and all appurtenances thereto, including all provisions made for the purpose of securing complete combustion of the fuel to be used and for the purpose of preventing smoke.

Section 15: It shall be unlawful for any person to use any new or reconstructed plant for the production and generation of heat and power, or either of them, until he shall have first procured a certificate from the smoke inspector that the plant is so constructed that it will do the work required and that it can be so managed that no dense smoke shall be emitted from the chimney connected with the furnace or firebox.

Section 16: No owner shall alter or repair any chimney or any old furnace or device which alteration, change or installation shall affect the method or efficiency of preventing smoke, without first submitting plans and specifications to the smoke inspector and securing a permit therefor, provided, however, that minor necessary repairs which do not increase the capacity of such plant or which do not involve any substantial alteration in structure and which do not involve any alteration in the method or efficiency of smoke prevention may be made by or under the engineer in charge of said plant without a permit. Any person who shall violate this section shall be liable to a fine of $25 for each day upon which he shall prosecute such alteration, change or installation without a permit, and each day's violation shall constitute a separate offense.

By virtue of this ordinance the Department of Smoke Inspection maintains a record of all new installations as well as all important reconstructions. The records of the department for the year 1912 show that during this year the department issued 263 permits affecting construction or reconstruction of furnaces under 485 boilers. These furnaces were divided as follows:

Hand-fired furnaces	323
Mechanical stokers	121
Gravity-feed furnaces	37
Oil-burning furnaces	4

Each group was subdivided as follows:

D. A. B. W. furnaces	206
McMillan furnaces (modified)	8
Extension hand-fired furnaces	19
Tile-roof furnaces	17
Defl. arches and semi-bit. coal	1
McGinniss arch furnaces	1
Dept. No. 4 furnaces	2
Twin fire-arch furnaces	29
Down-draft furnaces	13
Dept. No. 7 furnaces	22
Chain-grate stokers	68
Underfeed stokers	11
Taylor underfeed stokers	5
Side-feed stokers	15
Roney stokers	14
Swift stokers	6
Butman rotary-grate stokers	2
Waste heat hand-fired furnaces	4
Standard setting air ducts	1
Asphalt stills	3
Waste-heat mech. stokers	1
Burke & McKinzie furnaces	37
Total	485

From this table it can be seen that out of 485 furnaces only 19 were extension furnaces, and most of these were used to burn special fuel. In short, the dutch-oven type of furnace is not installed at present as a smoke preventer but is used to utilize fuels which can not be used in furnaces of a lower temperature, or to accommodate boilers which by the nature of their construction can not be equipped with any other type.

As to the third proposition advanced by Mr. Herzog, that is, "This action does not occur in other boilers that use distilled water, but have not that kind of a furnace." With the permission of Mr. Monnett, chief smoke inspector, Chicago, I sent a letter to various boiler-insurance companies, requesting information as to how the average condition of boilers in Chicago compared with other cities, and whether it was true that boilers in Chicago are subject to pitting more than the boilers outside of Chicago. Another question was, what percentage of boilers under observation in Chicago have this trouble to a marked degree, and how does it compare with the percentage in other cities?

In answer to this letter one company stated that its records do not show that the condition of boilers in Chicago, insofar as pitting goes, is any different than in most other sections of the country. The pitting of boilers in Chicago so far as this company's experience goes appears to be confined to that class of boilers used for cooking, heating or similar purposes in which the water of condensation is used over and over again. In all sections of the country, boilers operated under similar conditions are subject to pitting to a greater or less extent.

This company's inspectors, who work in Chicago and throughout the State of Illinois, report that there is no appreciable difference as to pitting, between the boilers operated in the city and boilers operated elsewhere in the state.

From another and well known company we received the following:

The average boilers in Chicago are probably in better condition than they are in some other locations, for instance, Pittsburgh, where pitting and corrosion are very marked. In Chicago we find but very little pitting and corrosion except in boilers used for heating purposes, where the pressure is low and the circulation is not very rapid, and where water is used from the returns, which naturally would cause considerable pitting.

We do not know what the percentage of pitting of boilers would be in Chicago, but we do know that the power boilers that we have inspected are probably freer from pitting than they are in most other localities, as we find that the water generally used for boiler-feed purposes is good.

From the above it can be seen that the statement of Mr. Herzog is wrong and that the feed water is more to blame than the furnace.

H. Misostow.

Chicago, Ill.

Referring to Mr. Herzog's letter in the issue of July 15, concerning the pitting of boilers, I am of the opinion that oxidation takes place both where the drop forms on the top plate and where it strikes the bottom plate.

If one crawls into the drum of a boiler free from scale and which has a leaky stop valve, it will be noticed that the vapor condenses on the sides and top of the drum. This condensation being chemically pure oxidizes the sheet both where the drop forms and falls.

Harry A. Cox.

Middletown, N. Y.

INQUIRIES OF GENERAL INTEREST

Circular Mil—What is the meaning of the term circular mil?

J. W. D.

A circular mil is the area of a circle 0.001 in. in diameter, or 0.0007854 sq.in., and is the standard unit of cross-sectional area of wires and cables for carrying electric current.

Condensing Surface—With brass condenser tubes of No. 18 gage thickness, cooling water at an initial temperature of 60 deg. F. and discharge temperature of 120 deg., how many pounds of steam per square foot per hour could be condensed?

J. W. D.

It would be considered good performance if 13 lb. per hr. were handled per square foot of condensing surface.

Highest Superheat—What is the highest temperature at which superheated steam is used?

S. E.

In this country a final temperature of about 500 deg. F. seems to be the practical commercial limit used in connection with steam turbines and poppet valve engines. In Germany temperatures of about 60 deg. F. are common and cases are on record where as high as 850 deg. F. has been used.

Resistance for Given Voltage Drop—What resistance is required to reduce a line voltage of 115 to 95?

J. A. P.

The amount of resistance required to reduce 115 volts to 95 volts will depend entirely upon the current. The drop across the resistance is $115 - 95 = 20$ volts, hence, from the formula

$$R = \frac{E}{C}$$

where

R = Resistance
E = Electromotive force or voltage
C = Current.

The resistance in ohms would be equal to 20 divided by the current in amperes.

Safe Flywheel Speed—At what speed (r.p.m.) can a 10-ft. flywheel be driven safely, having a rim with a 34-in. face, 3 in. thick? The wheel is in two sections and now runs at 90 r.p.m.

E. H.

In "Inquiries of General Interest," page 749 of May 21, 1912, issue of "Power," the method of determining the safe working speed of flywheels is given. With the strength of cast iron assumed as therein given, the safe speed would be 6085 ft. per min. for the flywheel rim. It is customary in figuring, however, to assume a mile a minute (5280 ft. per min.) as the limit of safe rim velocity in ordinary practice. A flywheel 10 ft. in diameter would have a circumference of 31.41 ft., and on the basis of a mile a minute, the safe speed would be $5280 \div 31.41 = 168$ r.p.m. The wheel being made in two parts, it must be assumed that the brackets or lugs and bolts for fastening the parts together have the same strength as the main body of the rim. If this is not so the safe speed would have to be taken as less than the above.

Thermal Efficiency—A steam engine develops 100 b.hp. consuming 500 lb. of steam in 10 min. If the temperature of the steam is 354 deg. F., its total heat 1190 B.t.u. per lb., and the temperature in the condenser 182 deg. F., what is the thermal efficiency, assuming the condensed steam to be returned to the boiler without loss?

S. S.

A horsepower being the development of work at the rate of 33,000 ft.-lb. per min., and 1 B.t.u. being equivalent to 778 ft.-lb., then

$$1 \text{ hp.} = \frac{33{,}000}{778} = 42.416 \text{ B.t.u. per min.}$$

and 100 hp. would be equivalent to 4241.6 B.t.u. per min. As each pound of steam supplied to the engine contains 1190 B.t.u. (reckoned above 32 deg. F.) and when returned from the condenser would be at 182 deg. F. (i.e. $182 - 32 = 150$ deg. above 32 deg. F.), then for each pound of steam used there would be supplied

$$1190 - 150 = 1040 \text{ B.t.u.}$$

and for the use of 500 lb. of steam per 10 min., which equals 50 lb. per min., the total heat supplied would be

$$1040 \times 50 = 52{,}000 \text{ B.t.u. per min.}$$

But as only 4241.6 B.t.u. was absorbed in performing useful work, the thermal efficiency of the engine would be

$$\frac{4241.6}{52{,}000} = 0.0815 \text{ or } 8.15 \text{ per cent.}$$

Steam from Pump—How can it be calculated how much steam will be required per day of 24 hr. by a duplex pump running at 75 r.p.m., having a piston 18 in. in diameter by 16-in. stroke, supplied with steam at 50 lb. pressure and exhausting into a vacuum of 20 in.

J. A. P.

The proper way to determine the steam would be to catch and weigh the condensate for a given time. It is not sufficient to estimate the weight from piston displacement as this does not allow for losses due to cylinder condensation and waste incident to clearance spaces. A rough method would be to estimate the horsepower developed and assume a rate of steam consumption. A duplex pump of the specifications given, with tight pistons and valves, should have a mean effective pressure on the pistons of about 65 lb. per sq.in., but for accuracy, the mean effective pressure should be determined by an indicator. Assuming 65 lb., the power developed in the steam cylinders would be

$$\frac{65 \times 1\tfrac{1}{2} \times 254 \times 47 \times 300}{33{,}000} = 200.5 \text{ hp.}$$

The water consumption of steam pumps of this kind varies with different designs, dryness of the steam supplied and mechanical construction. Under favorable conditions, using dry steam, the water rate would be about 35 lb. per hp. per hr., making the water consumption per 24 hr. run about

$$24 \times 35 \times 200.5 = 168{,}420 \text{ lb.}$$

Pipe Friction—Is there a simple formula for figuring the friction in a pipe line 500 ft. long, 12 in. in diameter with three 90-deg. ells and six 45-deg. ells?

J. A. P.

The formulas for flow of water in pipes are founded on mathematical deductions from experiments, and are not very simple. Elbow fittings vary in roughness and it is difficult to establish a law applicable to all cases. The friction of elbows is usually quoted in the number of feet of clean straight pipe of the same size which would cause the same loss of head as the fitting. The loss of head due to ordinary long turn ells (8 to 12 in. pipe) is taken as about equal to 4 ft. of pipe and for short turns about 10 ft. of pipe and 45-deg. ells would each be equivalent to about 7 ft. of the same size of pipe. The loss of head depends on the quantity or velocity of flow. With 3 short-turn ells (3×10 or 30 ft.) and six 45-deg. ells (6×7 or 42 ft.) the total loss in a line 500 ft. long would be equivalent to that in $500 + 30 + 42 = 572$ ft. of straight 12-in. pipe. A general formula for loss of head in feet is

$$h = f \times \frac{l}{d} \times \frac{v^2}{2g}$$

in which

h = Loss of head due to friction
f = Multiplier obtained by experiment which varies for different sizes of pipe
l = Length of pipe in feet
d = Diameter of pipe in feet
v = Mean velocity of flow in feet per second
g = 32.2, the acceleration of gravity.

Darcy's general formula, founded on extensive experiments, reduced to English units, is

$$h = \left(0.0199 + \frac{0.00167}{d}\right) \frac{l}{d} \times \frac{v^2}{2g}$$

In either of the formulas it is to be observed that the loss of head by friction is very nearly as the square of the velocity of flow and as the length of pipe. For rough calculations with small pipe it is quite common to figure the friction of an additional length of pipe as equivalent to each fitting.

ENGINEERS' STUDY COURSE

Evaporation—III

Equivalent Evaporation

By referring to the steam table published with last week's lesson it will be noticed that the total heat in a pound of steam gradually increases as the pressure increases. Thus, at atmospheric pressure the total heat of a pound of steam is 1150.4 B.t.u., while at 165 lb., abs., it is 1195 B.t.u. The heat required to generate steam at a pressure of 125 lb., abs., starting with feed water at 100 deg., is 1122.3 B.t.u. The proof is this: The total heat above 32 deg., as shown by the steam table is 1190.3 B.t.u. But 68 B.t.u. were already in the water because we started with the water at 100, instead of at 32 deg., and as 1 B.t.u. will raise the temperature of 1 lb. of water 1 deg., it is evident that (100 — 32) × 1 = 68 B.t.u. had already been supplied.

Then, the heat required to generate a pound of steam depends upon the pressure at which the steam is to be generated and the temperature of the feed water. It seldom happens that two boiler plants are exactly alike in both of these respects and, hence, when the performance of one plant is being compared with that of another, in order to be fair, it is necessary to have a common ground for comparison. One engineer might state, "I get an actual evaporation of 10.5 lb. of water per pound of coal," meaning that for every pound of coal fired into the furnace, 10.5 lb. of water were actually evaporated into steam under the conditions existing in his plant. He might think that he was making a better showing than his neighbor, who, although using exactly the same grade of coal, was getting an actual evaporation of 10 lb. per pound of coal. Yet, when the boiler pressure and feed-water temperature in both plants are taken into consideration, it might be shown that the man in the other plant was securing better efficiency even though the quantity of water actually evaporated per pound of fuel was somewhat less.

Assume that in the first-mentioned plant the steam pressure carried was 115 lb. per sq.in., abs., and the temperature of the feed water was 200 deg., while in the second plant the pressure was 190 lb., abs., and the feed-water temperature 100 deg.

In the first plant, the heat required to generate a pound of steam was

Total Heat in the Steam Above 32 Deg.		Heat in Feed Water Above 32 Deg.		
1188.8	—	168	=	1020.8 *B.t.u.*

And in the second plant the required heat was

Total Heat in the Steam Above 32 Deg.		Heat in Feed Water Above 32 Deg.		
1197.3	—	68	=	1129.3 *B.t.u.*

In the first plant 10.5 lb. of water were actually evaporated per pound of coal. Then, of the heat liberated by the combustion of 1 lb. of coal

$$1020.8 \times 10.5 = 10,718 \text{ } B.t.u.$$

were absorbed by the boiler and went toward useful work by generating steam.

In the other plant, 10 lb. of water were actually evaporated per pound of coal, yet

$$1129.3 \times 10 = 11,293 \text{ } B.t.u.$$

or 575 B.t.u. more were absorbed and went toward useful work than in the first case. Consequently, as the same quality of coal was used in each case, the efficiency of the latter plant was higher than the former.

This example emphasizes the importance of having a standard method of comparison so that the performance of all plants, no matter how widely the feed-water temperature and the steam pressure may vary, can be compared with complete fairness. The method used is to calculate the number of pounds of water that could be evaporated from a feed temperature of 212 deg. into steam at the same temperature by the heat used in evaporating 1 lb. of water from the feed temperature used in the plant discussed into steam at the pressure actually employed in that plant. The ratio of the evaporation at 212 deg. to the actual is called the "factor of evaporation." And when the number of pounds of water actually evaporated is multiplied by the factor of evaporation the product is the "equivalent evaporation" or the evaporation "from and at 212 deg."

The factor of evaporation may be found by the simple formula

$$F = \frac{(H - t) + 32}{970.4}$$

where

F = Factor of evaporation;

H = Total heat in the steam above 32 deg.;

t = temperature of the feed water.

Applying this formula to the first plant mentioned in the example just given, the factor of evaporation is found to be

$$F = \frac{(1188.8 - 200) + 32}{970.4} = 1.052$$

Multiplying together the pounds of water actually evaporated per pound of coal and the factor of evaporation, we have

$$10.5 \times 1.052 = 11.05 \text{ } lb.,$$

the equivalent evaporation per pound of coal. This quantity is called the equivalent evaporation because the heat put into 11.05 lb. of water at 212 deg. to make steam at 212 deg. (atmospheric, or 14.7 lb., abs., pressure) is exactly the same as the heat put into the 10.5 lb. at 200 deg. to make steam at 115 lb., abs., pressure. Hence, the two quantities are equivalent from the standpoint of heat.

Boiler Horsepower

The name horsepower was originally applied to the steam engine. James Watt, who did great work in the eighteenth century developing the steam engine, rated his engines as being able to do as much work as a certain number of work horses, hence, the unit, horsepower, which has been employed ever since. When it became

desirable to apply a unit to the output or capacity of a boiler, the same name was employed. Thus, a boiler which could supply steam enough to operate a 100-hp. engine was called a 100-hp. boiler. But such a standard without further qualification was very indefinite indeed. First, because various types and sizes of steam engines require widely different quantities of steam per horsepower-hour, and second, because a boiler of given dimensions may be made to generate steam at a greatly varying rate, depending on how hard the fire is forced.

Finally, an exact standard was selected and a boiler horsepower was established as the evaporation of 30 lb. of water per hour from a feed temperature of 100 deg. into steam at a pressure of 70 lb., gage, or the equivalent evaporation of 34.5 lb. of water per hour from and at 212 deg. This standard suffices to determine the output of a boiler when in operation, but it gives no means of determining the dimensions of a boiler for a given duty. In other words, a man who wished to purchase, say, a 200-hp. boiler, had no means by which he could calculate the area of the heating surface the boiler should possess and, hence, he was forced to depend upon the manufacturer's judgment. To avoid confusion and misunderstanding, it was, therefore, necessary to establish a standard for the area of heating surface necessary to develop one boiler-horsepower. At present, this standard is generally accepted as, 10 sq.ft. Thus, if a man purchases a boiler of 150-hp. rating, he expects to get a unit of such dimensions as to possess 1500 sq.ft. of heating surface. Heating surface is defined as that portion of shell, tubes and other parts which is in contact with the gases of combustion on one side and the contained water on the other.

Quality of Steam

Steam from practically all boilers, unless it passes through a superheater, contains moisture, that is, minute particles of water that has not been changed from its liquid form into the true vaporous state. By innumerable experiments it has been proven far beyond any doubt that when a pound of water at a certain temperature is evaporated into steam at a certain pressure a certain definite amount of heat is required. Now, then, if we condense a pound of what we assume to be "pure" steam (that is, saturated steam) by injecting it into a known weight of cool water and then carefully compute the heat it contained from the rise in temperature of the cooling water, we might find that the steam did not contain all the heat that, according to the steam table, it should. In such a case we would know that the steam contained "moisture" or was "wet."

The reason why a pound of wet steam does not contain all the heat it should is because the part that still exists as liquid water, no matter how fine or minute the particles may be, has not taken up any latent heat.

To illustrate with an actual numerical example, let us assume that we are investigating 100 lb. of wet steam that has been given off from a boiler at 125 lb., abs., pressure. According to the steam table, a pound of pure or dry saturated steam at 125 lb., abs., pressure should contain 1190.3 B.t.u. total heat above 32 deg., F., and, hence, 100 lb. should contain 119,030 B.t.u. If this 100 lb. were injected into 6000 lb. of water at 60 deg., the resultant weight of water would be 6100 lb. and the heat it should contain above 32 deg. would be the 119,030 B.t.u. before mentioned plus 6000 times the degrees difference between 32 and 60, or 168,000 B.t.u. One B.t.u. being the quantity of heat required to raise 1 lb. of water 1 deg., it is evident that

$$6000 \times (60 - 32) = 168{,}000 \ B.t.u.$$

would have to be put into the water in raising it from 32 to 60 deg. Thus, the total heat above 32 deg. contained in the 6100 lb. of water should be

$$119{,}030 + 168{,}000 = 287{,}030 \ B.t.u.$$

And, as the number of degrees in temperature above 32 deg. must be the total heat contained in the water divided by the weight of the water in pounds the new temperature after the steam has been injected should be

$$32 + (287{,}030 \div 6100) = 79 \ deg.$$

But, if the thermometer showed that the actual temperature was only 78.6 deg., and if there had been no radiation loss, it would be evident that there was a deficiency in the heat added to the water by the steam of

$$(79 - 78.6) \times 6100 = 2440 \ B.t.u.$$

Then, the entire 100 lb. of what we assumed was steam in actuality must have been only part steam and part liquid water.

Now, as the temperature of this liquid water carried in the steam is the same as that of the steam itself (if for no other reason than because the steam and particles of water arose together from the main body of water in the boiler), it is evident that the heat of the liquid is not deficient, the entire 100 lb. being at the boiling temperature. Consequently, the deficiency must all be due to the fact that some of the latent heat was not absorbed. This being the case, the number of pounds of water not converted into steam but simply floating in the steam in small particles (thus contributing to the weight of the mass just the same as though it all were steam) may be discovered by simply dividing the number of lacking B.t.u. by the latent heat of 1 lb. of steam at the given pressure, 125 lb., abs., thus,

$$2440 \div 874.7 = 2.8 \ lb.$$

Then, of the 100 lb. of what we assumed was steam only

$$100 - 2.8 = 97.2 \ lb.$$

or 97.2 per cent. really is steam. We say, consequently, that the "quality" of this steam is 97.2 per cent., or that the steam is "97.2 per cent. dry."

Practice Problems

A boiler is running under 120 lb., abs., pressure on feed water at 160 deg. What is the factor of evaporation?

If the actual total evaporation per hour is 8670 lb., what is the number of boiler horsepower being developed?

❖

Washington Coal Production in 1912—The coals of Washington have a wide range in character—from anthracite to lignite. The coking coals of Washington are the only ones of that grade on the Pacific coast. The coal-mining industry of Washington has suffered considerably during the last few years from the competition of fuel oil from California, the former principal consumers of Washington coal, the Puget Sound steamers and the railroads, having adopted petroleum for fuel. The production of coal in Washington reached its maximum in 1910, when the output amounted to 3,911,899 short tons, according to E. W. Parker, of the United States Geological Survey, who compiled the figures in cooperation with the Washington State Geological Survey. It decreased to 3,572,815 tons in 1911 and to 3,360,932 tons in 1912. The value fell off considerably less in proportion, from $8,174,170 to $8,042,871.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Wish folks would stop pestering the Panama engineers. A doubtless very wise old gentleman, quoted as being in charge of "enlarging the Amazon River's mouth," says the Canal is too shallow. Our veneration for old gentlemen on the shady side of 70 forbids our emitting a "spill" on an enlarged mouth, or we would bust right out in meeting.

⁂

Then, too, if the Canal engineers have to spend much more time answering the criticisms of newspapers and those engineers who know so much better how to dig it than the men on the job, we will never get it finished.

⁂

A good man and true heroically went to death in the hold of the "Imperator," after saving hundreds of lives. He was Second Officer Karl Gobrecht. And the irony of it all is that he was within a few feet of safety when the air tube of his smoke helmet and his guide rope tripped him in a companion-way filled with ammonia fumes and smoke.

⁂

They're toting out the old Missouri River again, proposing to dam it. Well, go ahead and dam it. Dam it, and dam it now! Show old Missouri!

⁂

Our mail at this writing has many postcards showing bright, level-headed engineers gazing into the distance—probably trying to see Springfield. Usually the cards have this legend. "Our worthy and esteemed brother, ——- ——-, is a candidate for the high office of," etc. Too bad they can't all be elected.

⁂

R. O. Richards, in the foreword "Engineer or Greaser?" of this issue, strikes deep into a big subject. Of course, you and I are corking good engineers, and the foreword does not include us. But, oh, the number of wild greasers we have known!

⁂

I've allus noticed thet some people air purty much like the guy'ner of an old Corliss—ther faster they try to go, ther higher up in ther air they git.—S. Kirlin.

⁂

McGraw's team the best-paid team we have? Only pikers! Why, Charley Naylor, chief engineer, the Marshall Field Co., just for a diversion, plays ball with the Chicago Retail Managers, whose salary checks would make $400,000 look like admission to the movies. We'd just like to see Chief Naylor pitted against Chief Meyers. Somebody would get massacreed!

⁂

The Union Street Ry. Co., of New Bedford, has equipped its storeroom employees with roller skates; says the skates are timesavers. Also that the "operator" can climb a ladder without removing the skates. Great!

⁂

He Wants an Explanation—Here is a letter from an anxious reader:

Gentleman—As I read on the cupon that the power com out every tuesday on the week, but as I have received Sunday sometimes monday and so on, and now is 2 weeks over Since I did not received anything at all why Such things happened I like to know your explanation

truly yours

MAX NICHTSAUS.

We've been explanationing all our long editorial life, but—Well, this stumps us. We'll wish this onto old Doc. Knowitall, the big cremo of the "Inquiries" department.

⁂

Cop's Courage Stops Disaster—Headline. Oh, you funny daily press! Read this extract:

"Policeman Krause and Street Sergt. Wassing, at the risk of their lives, daringly went through the cellar filled with hissing steam, and turned off a safety valve. A terrific amount of steam pressure was by that time confined in the boiler, and there was imminent danger of an explosion that might have killed several people."

Louis D. Brandeis on Central-Station Rates

SYNOPSIS—Based upon court decisions in parallel cases, Mr. Brandeis' opinion is that where the cost of producing and delivering electric energy is the same regardless of the quantity supplied, there is no legal justification for discrimination. Where there is a difference between the cost of making and delivering electric energy to wholesale and retail consumers, then the difference in the selling price may not be substantially greater than the difference in cost.

⁂

In a legal opinion submitted to the Uniform Electric Rate Association, Louis D. Brandeis holds that the present system of rates charged by the majority of central stations is discriminatory and therefore illegal. In arriving at this conclusion, he cites the court decisions in several parallel cases of both private and public-utility corporations. His opinion is in part as follows:

Where no specific statute controls the actual or relative price to be charged by electric companies for their service, the right to charge depends, of course, upon the common law; and no good reason exists why the rule governing the relation of electric companies to the public, in respect to charges, should differ from that governing the conduct of the business of other public-service corporations.

It is well settled that ordinarily every public-service corporation must give to all members of the public equal opportunities in rates as well as in service. A public service corporation may charge only a reasonable rate but no rate can be fair or reasonable which is discriminatory; that is, which gives to one class of users a preference over another class. This rule does not, of course, prevent a reasonable classification in use. It merely requires that all persons served under similar conditions shall be treated alike. The first question to be decided is therefore this: Is a use in large or wholesale quantities similar to a use in small or retail quantities? The answer to this question must depend largely upon matters of fact. If the cost of producing and delivering electric energy is the same per unit, regardless of the quantity supplied, all things being taken into consideration, then the user in large or wholesale quantities must be deemed to be taking the electric energy under substantially similar conditions, and no legal justification exists for discriminating between them.

The rule forbidding discrimination on the ground of mere quantity of service has been recognized for over 30 years in railroad transportation, having been laid down by Judge Baxter in the famous decision of *John Hays & Co. vs. the Pennsylvania Railroad.* In that case it appeared that the railroad company had fixed a rate between certain points at $1.60 per ton, with a rebate of from 30 to 70 cents per ton to all persons or companies shipping 5000 tons or more during the year—the amount of rebate being graduated by the quantity of freight furnished by each shipper. The railroad company contended that if the discrimination was made in good faith and for the purpose of stimulating the product and increasing its tonnage, it was both reasonable and just and within the discretion confided by the law to every

common carrier. The court, however, held the discrimination to be illegal, saying:

> The discrimination complained of rested exclusively on the right of freight supplied by the respective shippers during the year. Ought a discrimination resting exclusively on such a basis be sustained? If so, then the business of the country is in some degree subject to the will of railroad officials, for if one man engaged in mining coal and dependent on the same railroad for transportation to the market, can obtain transportation thereof at from 25 to 50 cents per ton less than another competing with him in business, solely on the ground that he is able to furnish and does furnish the larger quantity for shipment, the small operator will sooner or later be forced to abandon the unequal contest and surrender to his more opulent rival. If the principle is sound in its application to rival parties engaged in mining coal, it is equally applicable to merchants, manufacturers, millers, dealers in lumber and grain, and to everybody else interested in any business requiring any considerable amount of transportation by rail. A discrimination in favor of parties furnishing the largest quantity of freight and solely on that ground, is a discrimination in favor of capital, and is contrary to a sound public policy, violative of that equality of right guaranteed to every citizen, and a wrong to the disfavored party for which the courts are competent to give redress.

The mere fact that in the case of the wholesale customer for electric energy, the public-service company would be exposed to the competition of a possible isolated plant; whereas, in the case of the retail customer, there is no possibility of his supplying himself, does not afford any legal justification for difference in charge. In other words, the possibility of competition is not to be taken into consideration in determining the reasonableness of the classification. This proposition was also clearly stated in a decision of Judge Baxter in the case of *Handy vs. the Cleveland & Marietta Railroad Co.* In that case, the receiver of the railroad charged Wright, a refiner of oil, 35 cents freight per barrel, while it charged the Standard Oil Co. only 10 cents per barrel for a like service, and in addition gave it a rebate of 25 cents on all oil shipped by Wright. The justification offered for this discrimination was that the Standard Oil Co. owned a pipe line by means of which it controlled a large amount of space which the railroad wished to secure; that the railroad had to yield to the oil company's demands, for the company would otherwise extend its pipe lines and carry all the oil through them.

The Court held that these facts constituted no excuse for the discrimination, saying:

> Railroads are constructed for the common and equal benefit of all persons wishing to avail themselves of the facilities which they afford. All unjust discriminations are in violation of sound public policy and are forbidden by law, and except in the mode of using them, every citizen has the same right to demand the service of railroads on equal terms that they have to the use of a public highway or the government mails.

Assuming that there is a difference between the cost of making, delivering and selling electric energy between the wholesale and retail consumer, a public-service corporation can, in the absence of any statutes regulating or limiting the price at which it shall be sold, make a higher price to the retail customer, but the difference in the selling price may not be substantially greater than the difference in cost.

As to the right of a public-service corporation to make a substantial difference in its charges, based upon the broad purpose for which it is used, namely, a difference between light and power, there is more doubt. Some decisions of the state courts would seem to justify such discrimination, but the great weight of authority, as well as of reason, seems opposed to permitting any discrimination based upon the use to which the electric energy is put, and, therefore, upon the facts assumed in the question, such discrimination between charges for electric energy for power and charges for electric energy for light should be held illegal.

On the other hand, the difference between day use, when the demand upon the station is small, and evening use, when the demand upon the station is large, seems a proper basis of classification of service, and a court might, for this reason, upon the facts disclosed in a particular case, hold that the use for power, as calling mainly for day use, falls within a different class of service than use for light.

It seems clear, however, that mere difference in the value of the service or its character to the user, does not afford any justification for discrimination in rates.

Very closely in point are the decisions in regard to the supply of natural gas. In the case of *Bailey vs. the Fayette Gas Fuel Co.,* it was held that a natural gas company, organized to supply gas for lighting, heating and other purposes, has no power to make a difference in price according to the use to which the gas is put by the consumer; that is, making a lower price for gas used for power than where it is used for light.

In the case of the *Richmond Natural Gas Co. vs. Clawson,* the same decision was reached. There the company sought to fix the price of gas for fuel purposes at 12½c. per 1000 cu.ft., and to those consumers who used it for both fuel and illuminating purposes, at 20c. per 1000 cu.ft. The court held that this was unjust discrimination.

The Myriawatt

The following are extracts from a letter to the *Electrical World* from W. D. Weaver, its former editor, declaring against the advisability of adopting the myriawatt* as a unit of power:

> The absolute lack of any scientific basis for the proposed "new power unit" can easily be shown. It is absurd to endeavor to perpetuate, without possibility of further revision, a boiler power rating based upon an engine heat consumption per horsepower-hour corresponding to the thermal units in 34.5 lb. of steam evaporated from and at 212 deg. F.—this at a time when a lengthy search would have to be made to find an engine of such inferior efficiency, in a day when steam prime movers are sold on a guarantee, on the above basis, of less than 10 lb. of water, and when a claim is made for a figure below 8 lb. The decimal relation upon which the myriawatt rests is entirely fortuitous in any scientific, or even schoolboy, sense—the relation would actually be 20 or 30 instead of 10 if the horsepower rating of boilers more nearly corresponded with present-day engine efficiencies. The fundamental and sole base of the proposed "unit," the quantity 33,479, or approximately ten times the value of the kilowatt-hour in pound-Fahrenheit thermal units (3415), is merely the product of 34.5 (pounds of water) by 970.4 (thermal units to evaporate 1 lb. of water from and at 212 deg. F.) Any rating connecting a boiler with an engine which is based upon a standard evaporation is a scientific absurdity, for the reasons, among others, that there is no physical relation between the boiler evaporation and the specific steam consumption of an engine, and that the rate of evaporation which fixes the supply of energy to the engine depends upon many independent boiler variables, such as heating surface; ratio of grate to heating surface, type of boiler, kind and quality of coal, kind of draft, method of firing, etc. Scientifically and practically the "new unit" would have little more status than a hydraulic power unit based, in connection with a "standard" head, upon the size of a water-power dam.
>
> The myriawatt, does not in a single particular differ from the existing trade horsepower boiler rating except in name

*See the following issues for previous matter on the subject Aug. 27, 1912, p. 289; Jan. 21, 1913, p. 101; June 3, 1913, p. 800; June 24, 1913, p. 917.

and in an increase of about 2 per cent. in value. The grave practical fault of a boiler rating based upon a standard evaporation—a fault which has prevented the use of such a rating in Europe, has led to its entire neglect in this country by the marine engineering profession and by boiler designers, and to its little use by technically educated engineers in general—is that it does not even give a close clew to the size of a boiler for a specific service. For example, the boilers at the Detroit Delray generating station, which would be rated in the proposed nomenclature at 2365 myriawatts each, are said each to supply steam for the generation of 7500 kw. Again, a boiler of 100 myriawatts actual on the basis of natural draft and anthracite coal for fuel would, say, increase to 125 myriawatts actual with good soft coal, to 150 myriawaats actual with high chimney draft, and to 200, 300 or more myriawatts actual with forced draft.

Although a matter of relatively little moment, the name of the "new power unit" is also not free from objection, both as relates to the prefix "myria" and to the status of the "ten-thousand" metric multiple. While the word from which it is derived means, in Greek, ten thousand, in English it has the indefinite significance of "a great number." Even the French have halted at the "myria" metric nomenclature, which has never received practical adoption in France or elsewhere. The reason is perhaps that it was unconsciously felt to be illogical to use a unit that would compel one to think in terms of, say, four ten-thousands instead of forty thousand.

Dedication of Keokuk Plant

The huge dam across the Mississippi River and the waterpower plant at Keokuk, Iowa, described in our issue of Aug. 5, were formally dedicated on Aug. 26. The occasion was celebrated with a parade through the business streets, formal exercises at Rand Park, a regatta on Lake Cooper, the title given the artificial lake formed above the dam, and elaborate fireworks in the evening. Many prominent men made appropriate addresses, among them being Governor George W. Clarke, of Iowa, Lieutenant-Governor W. R. Painter of Missouri, Lieutenant-Governor W. L. Harding, of Iowa, former Representative William P. Hepburn and Judge William Logan.

A New Society for Uniform Electric Rates

Prompted by the knowledge that present central station activities are breaking into the legitimate field for their products, a number of manufacturers of small power-plant equipment have formed an organization known as "The Uniform Electric Rate Association." The sole object is to agitate for a uniform charge for electric energy, sold by central stations, by appealing to state public-service commissions and by prosecuting illegal rate discrimination by such corporations throughout the United States.

The membership is open to any mechanical or electrical engineer in public practice or any person, partnership or corporation engaged in the manufacture of individual power-plant apparatus. All expenses connected with the organization and the prosecution of its purposes are met by voluntary contributions.

NEW PUBLICATIONS

MANUAL FOR ENGINEERS. Compiled by Charles E. Ferris, Professor of Mechanical Engineering, University of Tennessee and published by the University Press. Size, 3x6 in., 170 pages; flexible leather. Price 50c.

This is in no sense an engineering handbook, but rather a little volume of vest-pocket size containing various useful tables and data such as the engineer is often called upon to use in solving problems offhand. It also contains instructions to be followed in the case of electric shock, shop injuries, antidotes for poison, etc., all of which should make the book useful to the active construction or operating man.

THE MOTOR AND THE DYNAMO. By James L. Arnold, Professor of Electrical Engineering, New York University. The Chemical Publishing Co., Easton, Penn., 1913. Cloth; 6x9 in.; 178 pages, illustrated. Price, $1.50.

Although intended to meet the needs of both the college student and the practical electrician, the book is written rather from the viewpoint of an instructor and is more adapted to the classroom than to home study.

The subject is introduced by a chapter on mathematical principles which is followed by a very lucid explanation of the current actions in the dynamo, after which the author plunges into the rudiments of design involving theory and mathematical treatment. It does not go far enough into the problems of design, however, to be of service to the electrical designer. Interspersed with these are practical considerations on the care and operation of dynamos.

The second half of the book deals with alternating current machinery, the elementary considerations of which are presented clearly. An attempt has been made, however, to cover too much ground in too little space which has made it necessary to only very briefly touch upon certain important classes of electrical machinery.

FACTORY LIGHTING. By C. E. Clewell. Published by McGraw-Hill Book Co., New York, 1913. Size 6x9 in.; 161 pages. Price, $2.

It is now generally recognized that good lighting is a large factor in practically all lines of manufacture, being an aid to good workmanship, health of the employees and a reduction in manufacturing costs. The book aims to tell in a simple way how to obtain good lighting, but instead of prescribing set rules, actual installations are made the basis for analysis and explanation so that they may be useful in similar problems under varying conditions.

Chapters are devoted to General Items and Requirements of Illumination Design, Lighting Installation Work, Lighting Maintenance and Records, Office Lighting, Drafting Room Lighting, Factory Lighting, Power House Lighting, Iron and Steel Mill Lighting and Machine Tool Lighting.

In the chapter on Power House Lighting, the engine room, boiler room, coal bins and conveyors, and the transformer, oil switch and busbar compartments are considered separately. Where the ceiling is low or of medium height it is shown that a large number of medium sized tungsten lamps give more satisfactory results; whereas with a high ceiling a smaller number of lamps of high candlepower are permissible.

SOCIETY NOTES

The regular meeting on Aug. 23 of Minnesota Association No. 2 (Minneapolis) of the National Association of Stationary Engineers was one of the best attended and most enthusiastic meetings it has held this year.

State-President Mueller, chief engineer, Washburn-Crosby Co., who was a delegate of the American Society of Mechanical Engineers to Germany, was present and gave an interesting and instructive talk regarding his trip. Immediately after his address he was presented with a gold watch charm by the association in appreciation of his efforts during the past year as chairman of the educational committee.

Peter Ulstrom, chief engineer of the C. A. Smith Lumber Co., who left Minneapolis for Oregon some months ago to act in the same capacity for the Smith interests in that state was also present, having returned to again assume charge of the Minneapolis plant. He presented the association with a hand-carved gavel, which he had made in Oregon.

Following the meeting all present were invited by State-president Mueller to an informal lunch at Schieks Café, and about 75 accepted the invitation.

At the next meeting of the association, September 12, Mr. Mueller will discuss the German and Swiss industries that he visited while abroad.

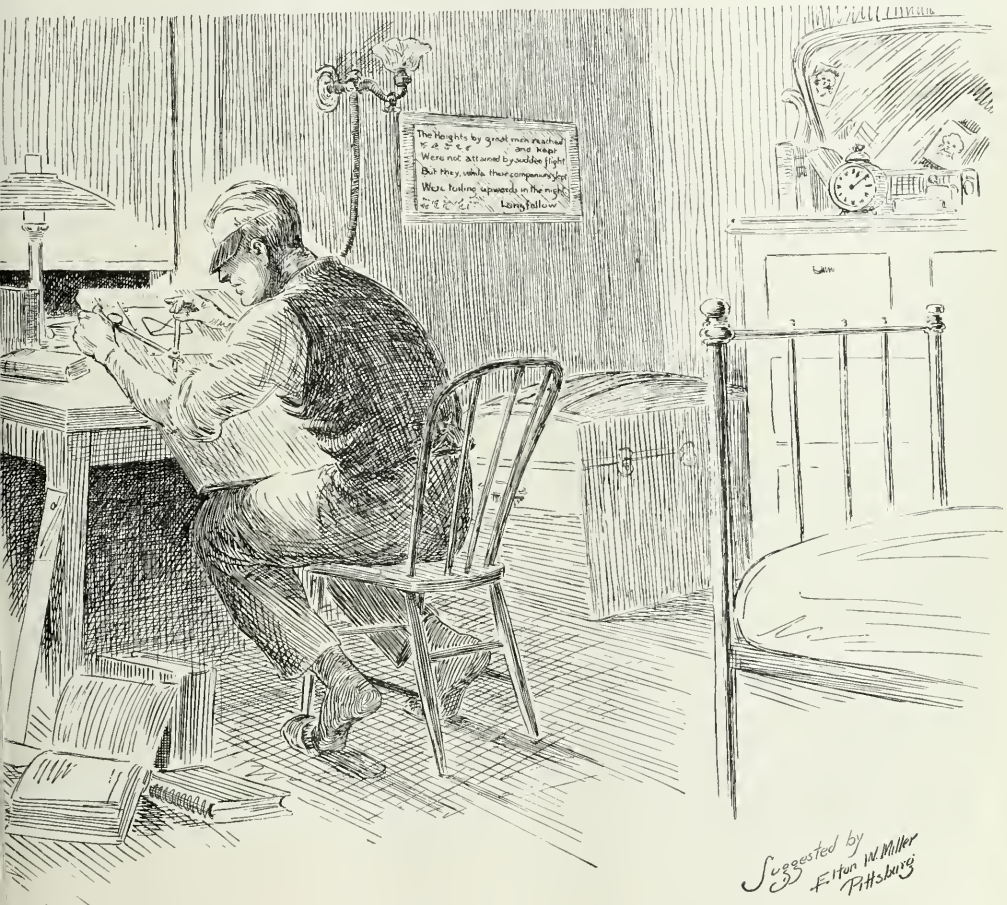
PERSONALS

Lockwood, Greene & Co., architects and engineers for industrial plants, 60 Federal St., Boston, Mass., have established a Canadian office under the name, Lockwood, Greene & Co., of Canada, Ltd., with headquarters in the McGill Building, Montreal.

Fred R. Low, editor of "Power," returned Aug. 28, from an extended trip abroad. After attending the joint meeting of the American Society of Mechanical Engineers with the Verein Deutscher Ingenieure, in Germany, June 19 to July 8, he visited the principal industries connected with the power field in that country and also in Switzerland, France, Belgium, England and Scotland.

POWER

Vol. 38 NEW YORK, SEPTEMBER 16, 1913 No. 12


The Heights by great men reached and kept
Were not attained by sudden flight
But they, while their companions slept
Were toiling upwards in the night
Longfellow
Suggested by
F. Hon W. Miller
Pittsburg

THE MAN WHO WILL SUCCEED

Coal Products Company's Power Plant

By S. G. Artingstall, Jr.

SYNOPSIS—The main features of this plant are found in the type of engines installed and the method of piping the units. Two live-steam headers run parallel with the boiler room. The size of the headers and branch pipes from the boilers are such as to prevent loss of pressure due to high steam velocity.

The Coal Products Co., Joliet, Ill., has recently put into operation, near that city, a new plant consisting of 35 Koppers improved byproduct coke ovens and other apparatus, having a daily capacity of 450 tons of foundry coke, 3,550,000 cu.ft. of illuminating gas, and the usual quantities of tar and ammonium sulphate.

A bird's-eye view of the plant, taken during the course of erection, is shown in Fig. 1. At the left are the office and byproducts buildings; the double building in the center is the power house, and in front of it the machine shop. The taller chimney is for the coke ovens, which at the time of photographing were not completed; the inclined conveyors carry coal and coke to their respective crusher and storage buildings. At the right is the crane for handling the emergency supply of coal,

Fig. 1. Birdseye View of the Plant

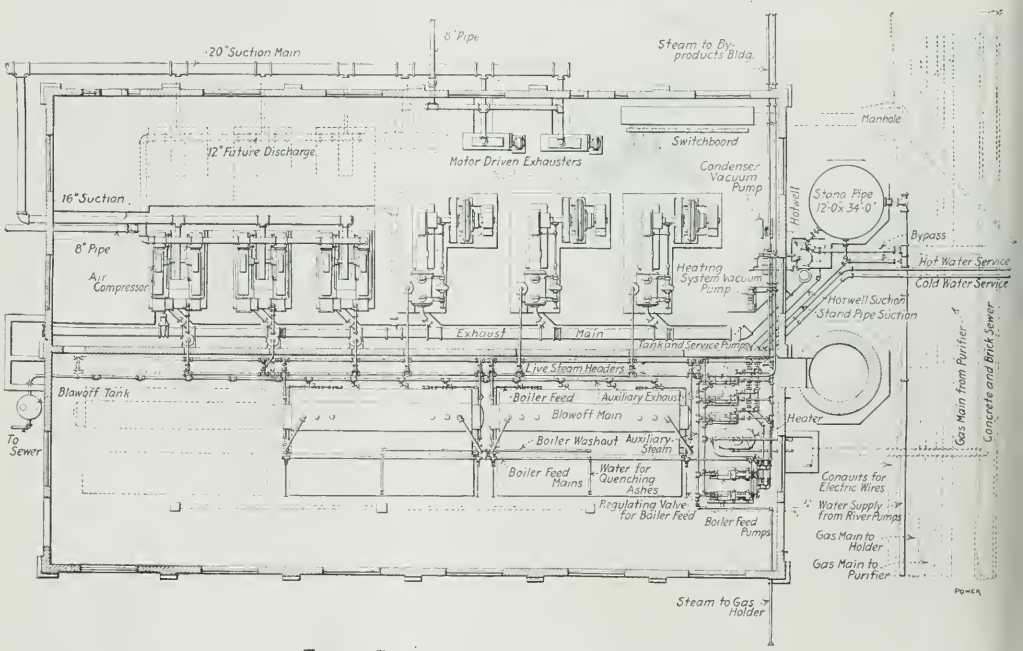


Fig. 2. Plan of Engine and Boiler Rooms

and in the distance is seen the Desplaines River and the Chicago Drainage Canal.

In a plant of this character, it is absolutely essential that an uninterrupted supply of water and electric current be maintained, and although the equipment in the power house is more or less standard, some interesting features are brought out in the design of the piping systems, which are made in duplicate or as interchangeable as possible, so that a complete shutdown will not be necessary in order to make repairs.

Building

The building, comprising the boiler and engine rooms, a plan of which is shown in Fig. 2, is 78x120-ft. inside dimensions. It is constructed of red pavers over common bricks, which are left rough in the boiler room and plastered in the engine room—the latter being painted green to a height of 10 ft. above the floor, and the balance calcimined white. The roof has steel trusses and purlins on which is laid a covering of cement tiles. The rock

comes to the surface of the ground at this point, therefore no basement is provided, both floors being placed on the same level—as shown in Fig. 3. All underfoot piping is placed in trenches covered with removable checkered steel floor plates.

Boiler Room

The boiler-room equipment consists of four vertical water-tube boilers, designed for 160-lb. working pressure, rated at 305 hp. on the basis of 10 sq.ft. of heating surface per horsepower; they are equipped with superheaters to give 125 deg. of superheat. The settings are special, in that the dutch-oven furnaces are extended to give 88 sq.ft. of grate surface. The grates are the pin-hole type with $\frac{5}{16}$-in. holes, the fuel used being coke breeze, hand fired.

The boilers are arranged in two batteries of two units each, space being left for one future battery. An 8x175-ft. radial brick chimney furnishes the draft, aided by a 20-in. turbine blower for each boiler. The blowers are set in the outer casing of the boilers and deliver air through the hollow bridge-wall to openings under the grates, the supply being regulated by dampers operated from the front of the furnaces. The speed of the blowers is governed by a damper regulator, but the dampers in the uptakes to the smoke breeching are adjusted by hand.

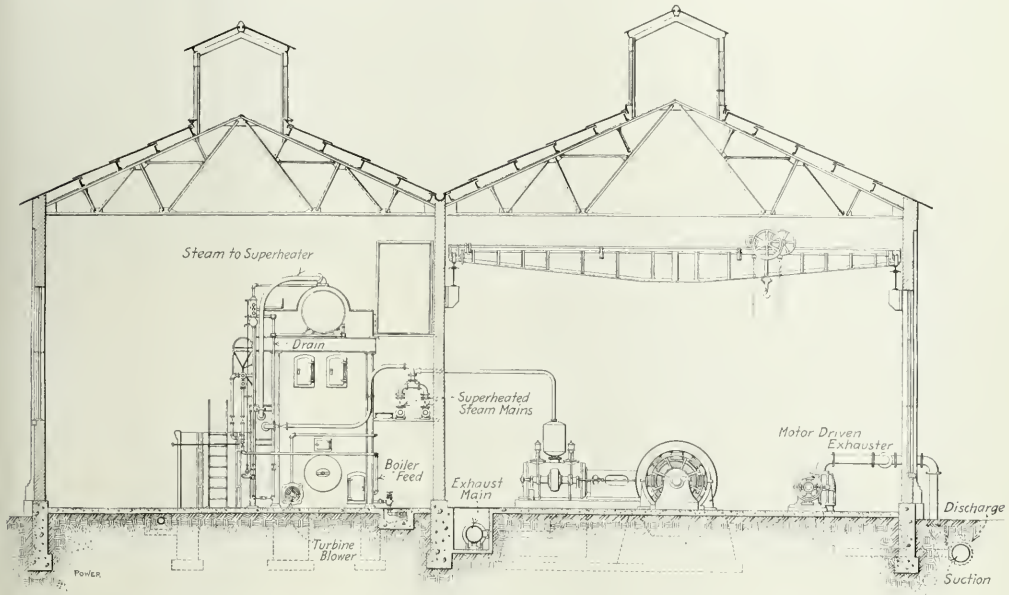


Fig. 3. Elevation of Boiler and Engine Rooms

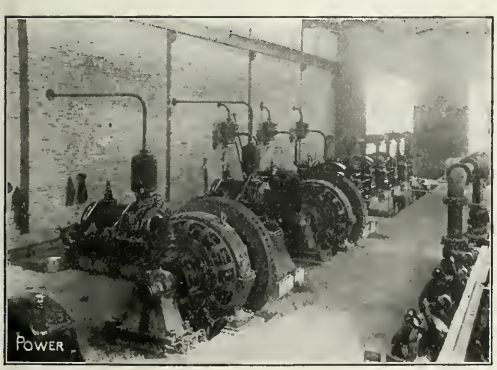


Fig. 4. Engine Room

The boiler feed, tank and service pumps and the heater are arranged in a row at the end of the boiler room, as indicated in Fig. 2.

Engine Room

In the engine room, Fig. 4, there are three 19x21-in. Lentz engines, directly connected to three 250-kw., 250-volt D.-C. generators.

The power is distributed through a 10-panel marble switchboard, Fig. 5, thence by an underground system to the various buildings about the plant.

Three cross-compound, single-stage gas compressors compress the gas to 40 lb. per sq.in. and deliver it to an 8-in. main leading to Aurora and the more distant towns.

Two rotary blowers of 4.2 cu.ft. per revolution capacity furnish gas to the low-pressure system for the City of Joliet. One of these blowers is coupled to a 25- and the other to a 7½-hp. 230-volt D.-C. motor, the latter being used as a spare unit.

The dry-vacuum pump for the condenser and the heating-system vacuum pump are also located in the engine room. An 18-in. barometric condenser is situated just outside the building at the end of the main-exhaust line from the engines and compressors.

Water Piping

All piping connecting with the pumps and heater is arranged to give the maximum flexibility, and at the same time is simple. The two service pumps and the heater pump are interchangeable, and can take water from the standpipe or hotwell and deliver it to the hot- or cold-service system or to the heater, or all the pumps can be bypassed and the heater take its supply directly from the standpipe by gravity.

Both boiler-feed pumps can take water from the standpipe, hotwell or heater; while one is feeding the boilers, the other may be delivering water for washing purposes. There being two mains running parallel to and in front of the boilers for these requirements. A hose connection for each battery and the boiler-feed branches to each boiler are connected to both of these mains.

Pump House

The house and the pump supplying water to the standpipe are situated about 1000 ft. away. A channel blasted out of the rock connects the suction pit to the main channel of the river. The equipment consists of two motor-driven 8-in. centrifugal pumps, each connected through automatic starters to float switches in the standpipe. One of the floats is situated near the top at the regular water line, and the other about half-way down, so that if the upper one fails to operate, the lower one will cut in the idle motor before the standpipe is empty. A double-throw switch on the panelboard in the pump house reverses the floats, and is thrown once a month so that each motor gets an equal share of the work.

Live-Steam Piping

The system of live-steam piping consists of two headers, running parallel to and in back of the boilers to the end of the boiler room, then turning at right angles and continuing to the byproducts building, as shown in Fig. 2. Connections to these headers are made from the boilers and to the engines, Fig. 3. A U-bend in each header, about in the center, takes care of the expansion, which is divided up by means of anchors; a walk on a level with the headers gives a means of easy access to all the valves.

Full-weight pipe is used with semi-steel screwed flanges, semi-steel fittings and valves, the latter having nickel seats, disk rings and nickel-steel rising stems. A double-thick covering of 85 per cent. magnesia insulates the entire system.

In designing the live-steam piping, advantage has been taken of past experience, which has shown that the usual rule of a velocity of 6000 ft. per minute would not apply for superheated steam, on account of the excessive loss in temperature at the throttle; on the other hand, it is well known that as the velocity increases the pressure decreases, until the advantage gained in holding the superheat is more than offset by the resulting drop. Therefore, a medium has been struck between these two extremes, and 4-in. pipes for the headers and branches from the boilers, and 3-in. pipes to the receivers were installed. The receivers are of ample capacity to prevent fluctuations and wire drawing, and are heavily lagged with 85-per cent. magnesia. Receivers for the engines are placed directly on the throttle and those for the compressors on the wall.

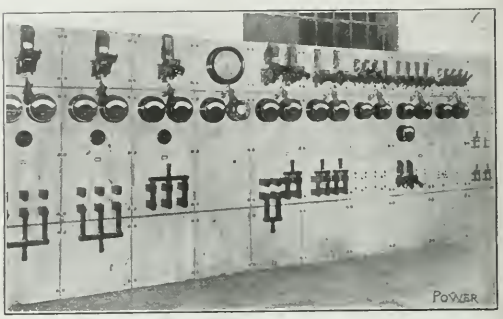


Fig. 5. Switchboard

It was considered more economical, from the standpoint of upkeep, to operate the compressors with less superheat than that used for the Lentz engines, which are made especially for high superheat. The receivers for the compressors are, therefore, placed on the wall and some distance away and connected to the throttle with a 5-in. pipe to reduce the velocity of the steam. Provision is also made to keep a stream of water circulating through these receivers to kill the superheat, if it is found necessary.

This system has fulfilled all expectations, as shown by actual operating conditions; the drop in pressure is slight, and very little superheat is lost. The receivers, acting as reservoirs, counteract any disadvantage due to the smallness of the piping, and at the same time the total radiating surface is reduced fully 30 per cent. Another advantage is the cost; the smaller fittings, valves, etc., creating quite a saving.

PRINCIPAL EQUIPMENT OF THE COAL PRODUCTS CO.'S POWER PLANT

	Equipment	Type	Purpose	Kw.	Volts	Amp.	R.p.m.	Size	Pres.	Hp.	Manufacturer
4	Boilers	Vert. W.T.	Steam Generation						160	305	Erie City Iron Works
4	Superheaters	Foster	125 degrees S.H.						160		Power Specialty Co.
	Grates	Pin-hole	Furnace								Erie City Iron Works.
4	Blowers	Turbine	Draft				Variable	20 in.	160		L. J. Wing Mfg. Co.
1	Regulator	Spencer	Blowers								Thompson, Richards & Co
1	Chimney	Radial Brick	Draft					8x175 ft			Heinicke Chimney Co.
3	Engines	Lentz, Simple	Main Units				200	19x21 in	150	325	Erie City Iron Works.
3	Generators	Direct Current	Main Units	250	250	1000	200				Westinghouse Elec. & Mfg. Co.
3	Compressors	Single-Stage Compound	Gas				Variable	14x24x16 18x16 in.	150		Ingersoll-Rand Co.
2	Blowers	Rotary	Gas				Variable	4.2 cu.in.			Connersville Blower Co.
1	Condenser	Barometric	Main Units					18 in			Alberger Condenser Co.
1	Pump	Dry Vacuum	Condenser								Alberger Condenser Co.
1	Pump	Vacuum	Heating System								Consolidated Engineering Co.
2	Pumps	Duplex O C P	Boiler Feed					10–6–10 in.			Canton Hughes Pump Co
3	Pumps	Duplex	Service & Heating					8–8½–10 in.			Canton Hughes Pump Co
1	Heater	Open	Boiler Feed					4			Stillwell-Bierce & Smith-Vaile Co.
3	Governors	Fisher	Service Pumps					¾ in			Fisher Governor Co.
1	Switchboard	Marble	Electrical Distribution					10 pan			J. Lang Electric Co

Exhaust Piping

Exhaust steam from the prime movers is carried in a 5-in. main at the compressors, increasing to 18 in. at e engines, and is made of ¼-in. material with van-one joints. Expansion is taken up in corrugated-cop-r expansion joints.

The condenser at the end of the exhaust main gives a 3-in. vacuum, with the aid of a dry-vacuum pump. The condenser draws its injection water directly from the standpipe, by means of its own vacuum.

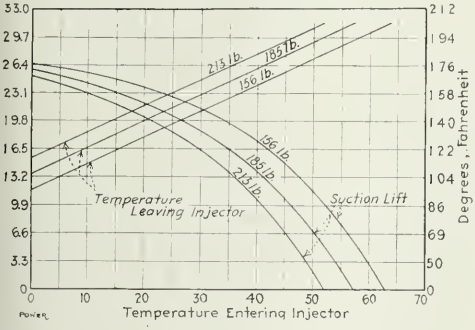
Exhaust steam from the auxiliaries is carried to the heater, which raises the boiler-feed water to about 200 deg. F.

The plant, as a whole, has proved very economical as to operation and maintenance, and the live-steam piping is rather exceptional when compared with the piping usually found in the average power house.

Feed-Water Heating for Locomotives*

YNOPSIS—Feed-water heating is first considered as its beneficial effects on the boiler and the requirements a good heater are set forth. Finally, comparative re-lts are shown for locomotive practice of the savings om feed-water heating when using saturated steam, oderate superheat and high superheat.

One practical advantage occurring from the use of a ed-water heater is the greater protection given the oiler by reason of the lesser temperature changes. While eam at 170 lb. gage has a temperature of about 375 deg. , that of the water in the tender usually rises but little ove the temperature of the water taken in, and in win-r the water in the tender is cooled down to near the



IG. 1. Comparison between Temperature of Feed Water Entering and Leaving Injector; Also Theoretical Suction Lift

eezing point. Of course, feeding is not done at this low mperature, for with the injector the water is warmed rhaps 72 to 90 deg. Nevertheless, in winter there are be found in the boiler all temperatures between 120 d 375 deg. F. These temperature changes give rise distortions resulting in leakage at the rivet joints and the tube-sheet. When feeding with water heated to 5 deg. the temperature in the boiler remains more uni-rm. In this case, between the points of lowest and ghest temperatures there obtains a difference of, say, 5 — 265 = 110 deg. against 375 — 122 = 253 deg. thout a heater. A further safeguard, introduced by the e of a feed-water heater, is that the sediment and scale e no longer deposited alone in the boiler but to a large extent in the heater where they are less injurious.

From the foregoing, two essentials may be advanced as necessary in the design of the heater. First, it should permit of the deposit of the sediment at some dead point that it may not be carried into the boiler where it might prove troublesome at the check valve, or injure the injector or the pump if these latter be located between the heater and the boiler, and the construction should be such as will readily admit of cleaning. However, scale which may develop on the heater shell is harmless, as the metal is not exposed to the action of the fire. From the standpoint of easy cleaning preference is to be given to that type of heater where the water flows through straight tubes rather than to that where the tubes are surrounded by the water, and also to comparatively large tubes rather than small ones.

In addition to the mineral matter separated from the water by the heater the dissolved air and carbonic acid are expelled; this also operates strongly toward preservation of the boiler surfaces, and in locomotives provided with feed-water heaters pitting and the formation of rust are decidedly less marked.

Preheating the feed water avoids the sudden pressure drop in the boiler on starting the injector. Along with the advantages of simplicity, light weight and small space requirement the injector has the disadvantage that in practice its delivery volume can be but slightly varied. On grounds of safety it is proportioned to meet the maximum demand possible and is thus only intermittently in use, whence its steam consumption is large as its efficiency is only 5 or 6 per cent. Added to the high steam consumption under forced duty, 8 to 9 per cent. of that of the engine, the introduction into the boiler of comparatively low-temperature feed water induces pressure drops which are very annoying under operating conditions. If the injector forces the feed through a heater before entering the boiler, or if it be drawn through one by a pump, and raised to a temperature of 212 to 265 deg. the pressure drops in the boiler while feeding are materially lessened.

The theoretical suction lifts of the injector and the discharge temperatures due to the suction temperatures are shown in Fig. 1 for boiler pressures of 156, 184 and 213 lb. The results attained in practice do not fully agree with the values given, owing to incomplete condensation in the injector and heat and friction losses. The actual temperatures of delivery lie somewhat higher; the suction heights somewhat lower. In any case the temperature of the discharge is certainly below 212 deg. F. With a feed-water temperature of 50 deg that of the dis-

*Translated in abstract by Wm. F. Monaghan from a re-nt contribution to "Zeitschrift des Vereines Deutscher In-nieure," by Ludwig Schneider.

charge from the injector, under normal conditions, is about 110 deg.

The ordinary injector refuses to lift water at a temperature of 101 deg. F. The manipulation of the so called hot-water injector, which operates with a suction temperature of even 212 deg., is too complex for use so far on locomotives. Steam pumps used for feeding deliver, under usual boiler pressures, from 100 to 150 lb.

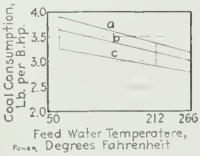


FIG. 2. COAL CONSUMPTION OF SIMPLE ENGINE AS DEPENDENT ON FEED-WATER TEMPERATURE

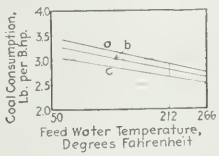


FIG. 3. COAL CONSUMPTION OF COMPOUND ENGINE AS DEPENDENT ON FEED-WATER TEMPERATURE

of water per pound of steam consumed as against only 15 lb. by an injector. In addition the exhaust from the pump can be utilized for heating the feed water, and its delivery volume can be simply and positively varied within wide limits.

ECONOMY AND THEORY OF PREHEATING

The process of heat transfer from the hot gases to the boiler contents resolves into two divisions, or with compound engines into three. In the first place the water must be heated to the evaporating temperature. This, with a boiler pressure of about 213 lb., is represented by 392 deg. To heat the feed water from 50 to 393 deg. there must be supplied to each pound approximately 343 B.t.u. The latent heat of evaporation under these conditions amounts to 833.5 B.t.u. The total heat expenditure for the generation of steam at a pressure of about

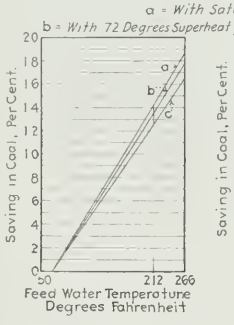


FIG. 4. SAVING IN COAL THROUGH HEATING FEED WATER WITH SIMPLE ENGINE

FIG. 5. SAVING IN COAL THROUGH HEATING FEED WATER WITH COMPOUND ENGINE

213 lb. from 1 lb. of water at a temperature of 50 deg. is thus

$$343 + 833.5 = 1176.5$$

If the steam be superheated to 600 deg. there will be the further requirement expressed by the product of the temperature increase and the average specific heat; or for the foregoing,

$$(600 - 393) \times 0.552 = 114.2 \ B.t.u.$$

Under this assumption the total heat absorption amounts to

$$1176.5 + 114.2 = 1290.7 \ B.t.u.$$

Now if the feed water be heated first by exhaust steam to 212 deg., there will result a saving of 162 B.t.u. The heat transfer within the boiler is lowered, in the case of saturated steam, by 13.8 per cent., and in the case of superheated steam by 12.5 per cent., and assuming that preheating of the feed water does not change the efficiency of the boiler these values represent at the same time the saving in fuel. As a matter of fact, due to the maintained cleanliness of the boiler, resulting from the use of a heater, its efficiency is raised and the percentages given will even be exceeded. The values presented in

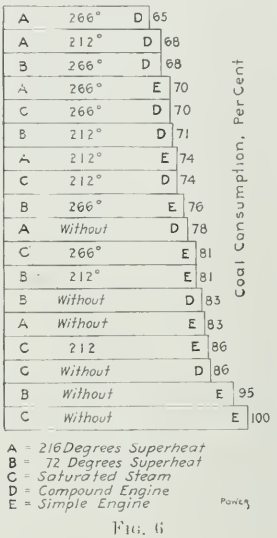

A 266° D 65
A 212° D 68
B 266° D 68
A 266° E 70
C 266° D 70
B 212° D 71
A 212° E 74
C 212° D 74
B 266° E 76
A Without D 78
C 266° E 81
B 212° E 81
B Without D 83
A Without E 83
C 212 E 86
C Without D 86
B Without E 95
C Without E 100
Coal Consumption, Per Cent
A = 216 Degrees Superheat
B = 72 Degrees Superheat
C = Saturated Steam
D = Compound Engine
E = Simple Engine
POWER

FIG. 6

Figs. 2 to 6 for constant boiler efficiency are, however, calculated without reference to this favorable condition. Also for the assumed boiler efficiency and steam consumption it was sought to maintain coal-consumption values easily reached in practice, so that there is no room for distrust of the calculated results. The heat value of the coal is estimated at 12,625 B.t.u., and the boiler efficiencies, inclusive of the superheaters for (a) as 70 per cent., for (b) as 70 per cent., and for (c) as 67 per cent.

The simple engine, with saturated and with superheated steam, may be first considered. When operating without preheating the feed water, superheating the steam results in a coal saving of 15.5 per cent.; with coincident preheating and superheating this saving drops in a remarkable way to 13 per cent., and with the feed water preheated to 266 deg. F. the saving amounts to only 12.5 per cent. Thus the influence of feed-water heating on the utility of superheating, insofar as it is expressed in coal consumption, is similar to that of multiple expansion; that is, it lessens the relative economies so little that there is no question of the virtue of superheating.

A like consideration of the compound engine shows that high superheating without feed-water heating yields a saving of coal of 10.5 per cent. as opposed to saturated

steam. Heating the feed water to 212 deg. F. shows a saving of 8 per cent. and with preheating to 266 deg. a saving of 7.5 per cent. The law thus holds good for both simple and compound engines.

Based on the coal consumptions, as of Figs. 2 and 3, a graphic series may be arranged as in Fig. 6 for simple and compound locomotives using saturated or highly superheated steam or with a steam dryer. These show 18 different conditions of operation, from the simple engine using saturated steam and without feed-water heating

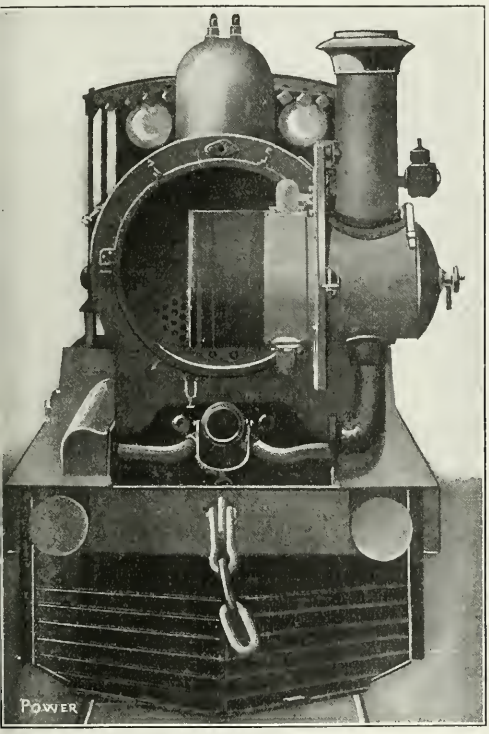


FIG. 7. LOCOMOTIVE WITH FEED HEATER IN UPTAKE

and burning 3.85 lb. of coal per horsepower-hour measured at the rail, to the compound engine using steam of high superheat and with preheated feed water and consuming 2.508 lb. per hp.-hr., a ratio of 100 to 65.

A feed-water temperature of about 212 deg. F. can be reached by condensing in a suitable heater the exhaust from the air and boiler-feed pumps and using in addition part of the main exhaust. To heat a given quantity (F lb.) of feed water from 50 to 212 deg. there will be needed, of dry exhaust steam, an amount represented by the quotient of the latent heat of steam at atmospheric pressure into the temperature range of heating, or

$$F\,\frac{162}{970.4} = \frac{F}{6}$$

In other words, for preheating, about one-sixth of the exhaust is necessary. The air-pump exhaust may be estimated at 3 per cent. of that from the engine cylinders per hour; the boiler-feed pumps, with an hourly feed delivery of F pounds, will furnish in pounds of exhaust steam about

$$\frac{F}{100}$$

then if these quantities be supplied to the heater there will be a further requirement of about one-eighth of the main exhaust. In view of the moisture in the steam this figure will be somewhat increased so that it may be taken as one-seventh of that exhaust when operating with superheated steam and one-sixth with saturated steam. In general it will be of advantage to regulate this quantity of steam to suit the amount of feed at any given time in order that the blast may not be unnecessarily depreciated.

The heat-transferring surface of the heater may be calculated by means of the formula

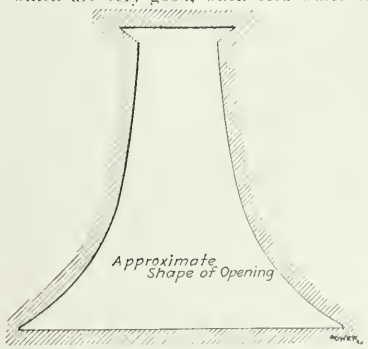
$$S = \frac{Q}{ct}$$

where S is the heating surface in square feet; Q the quantity of heat to be transferred per hour in B.t.u., c the coefficient of heat transference, and t the average temperature difference of the steam. The area thus obtained is to be increased by a certain amount to allow for losses due to incrustation and to outward radiation; an amount dependent on the hardness of the water and the design of the heater. This method gives a heating surface for the feed-water heater of about $^1/_{12}$ to $^1/_{18}$ of that of the boiler.

The author refers to feed-water heaters utilizing the waste gases and used alone or in combination with those where heat is absorbed from the exhaust steam, and includes a number of other curves and formulas and reproductions of interesting drawings and photographs of domestic and foreign practice, notably the Gaines method used on the Central of Georgia R.R. in this country, employing both of the types of heaters referred to and a reciprocating feed pump, and the odd designs in use on the Egyptian State Railroads, one of which is shown in Fig. 7.

Compensating Device for Water Measurement

There are a number of water meters on the market, some of which are very good, when cold water only has



COMPENSATING NOZZLE

to be dealt with, but the number of meters which can accurately integrate and record the flow of hot water such as boiler feed in the hot-well tank in the power

house is limited. Of those which give the best results, probably the most successful form is that which depends for its measurement on the flow of water over a weir or notch.

Considering this flow, the law connecting the rate at which the water is discharged over the weir and the depth of water over the weir is in the nature of

$$R = K S \sqrt{D}$$

where

R is the rate of discharge at any time;

D is the depth of water over the weir;

S is the submerged area of the weir;

K is a constant which includes the coefficient of discharge.

It will be seen that this is a complex formula, in which one of the variables follows the square-root law. Where each rate of discharge has to be calculated independently, the expression is sufficiently simple to allow the calculation to be carried out easily, but for an integrating or recording instrument in which measurements have to be taken continuously and automatically, the next step in the simplification of the instrument is to eliminate, if possible, the square root in the foregoing expression.

In the instrument constructed by Alexander Wright & Co., London, a device has been applied which consists in making the oritice of the weir somewhat in the form illustrated herewith, in which the breadth of the weir is made inversely proportional to the square root of the corresponding depth at any level, with the result that the depth becomes directly proportional to the flow. The sides of the notch are obviously a logarithmic curve. With this notch it is possible, by means of a float and connection to a recording pen on a rotating drum to draw curves showing the rate of discharge at any instant on an evenly divided vertical scale, and a curve of this description is obviously much more simple of measurement than one in which the vertical heights follow the square-root law.

A second device is incorporated in the water meter as regards the method of integrating. A ground-glass plate is mounted in a horizontal position in gear with the clock which drives the chart drum. This revolves on a vertical axis at a uniform rate. The float rod which is moved upward or downward in accordance with the depth of water in the weir, has connected to it a small index and driving wheel which is moved outward from the center of the glass as the float rises. The wheel is rotated by friction with the ground-glass disk, and obviously the further out that it proceeds from the center of the disk the more rapid is its travel in a given time. In this way the number of rotations of the index wheel in a given time is varied automatically, and through a very fine series of gradations according to the variations of the depth of water in the weir. The action is accurate, immediate and simple, and in this way the integration is readily obtained.

It will be seen therefore that this "Precision" water meter is capable of being adapted to a large range of water measurements, the rate of flow being indicated on the chart and the total amount of water being shown on the index in plain figures.

Distribution of Heat in Steam Boilers*

SYNOPSIS—A study of the losses encountered in the steam boiler and some test results, showing how the boiler efficiency was increased.

In accordance with the recent recommendations of the power-tests committee of the American Society of Mechanical Engineers, a balance accounting for the distribution of heat in a pound of dry coal fired consists of the following items: 1. Heat absorbed by the boiler. 2. Loss due to evaporating and superheating moisture in coal. 3. Loss due to evaporating and superheating moisture formed by the combustion of hydrogen and distillation of oxygen-hydrogen compounds in the coal. 4. Loss due to heat carried away by dry flue gases leaving the boiler. 5. Loss due to heat escaping through the formation of carbon monoxide (CO). 6. Loss due to combustible removed from ashpit and from grates during cleaning. 7. Loss due to superheating moisture in the air used for combustion. 8. Loss due to unconsumed hydrogen and hydrocarbons, to radiation and unaccounted for.

Heat Carried Away by Flue Gases

Of the items enumerated, 4, 5 and 6 generally constitute about 75 per cent. of the heat lost, and are the variable factors which have a direct effect on the percentage of heat imparted to the water. The loss which is generally the largest and in the majority of cases most easily reduced is the heat carried away by the dry flue gases escaping from the boiler. Under this heading are included the sensible heat in the carbon dioxide and carbon monoxide, if any, and the heat in the excess air. The loss depends upon the weight of gases per pound of carbon burned together with the temperature at which the gases leave the boiler. The data which are required for this computation are the temperature of the flue gases, temperature of the boiler room, composition of the flue gases, the heat value of the coal and the carbon content of the fuel and ashpit refuse.

Several tests conducted in a plant in which the loss of heat in the flue gases was originally high are submitted in Tests A of Table 1. The plant in question consisted of hand-fired horizontal return-tubular boilers equipped with plain grates upon which Pennsylvania semibituminous coal, containing about 9 per cent. of ash and 22 per cent. of volatile matter, was burned. The fires were carried at a thickness not exceeding 7 in. and were uneven, thereby permitting a large air excess. Increasing the thickness of the fire and altering the methods of firing resulted in a reduction of the loss of heat due to excess air from 36 to 12 per cent., with a resultant increase of about 20 per cent. in the boiler efficiency.

Loss from Carbon Monoxide

The loss of heat due to the incomplete combustion of carbon to carbon monoxide is usually an important fac-

*Presented by Perry Barker, fuel engineer of Arthur D. Little, Inc., at the fifth semi-annual meeting of the American Institute of Chemical Engineers, Boston, Mass.

tor. While the presence of carbon monoxide shows that some heat is lost through incomplete combustion, a small percentage of this constituent generally indicates that the air excess is reduced as low as practicable. A small amount of smoke, as evidence of the presence of carbon monoxide, is a more convincing indication of economical furnace operation than a smokeless stack which may be emitting several hundred per cent. of excess air.

The extent of this loss is dependent upon the percentages of carbon monoxide and carbon dioxide as determined by the flue-gas analysis, the heat value of the coal and the percentage of carbon in the coal fired and in the ashpit refuse.

Results of several tests in a plant where the loss due to unburned gases, as indicated by the presence of carbon monoxide was particularly high, are shown in Tests B of Table 1. The boiler equipment consisted of hand-fired vertical tubular boilers having shaking grates. Coal from the Georges Creek field, containing approximately 18 per cent. of volatile matter was burned. The high loss due to incomplete combustion was not attributed to the character of the coal, although it had been proved that the furnace space in the boilers was not sufficient to burn coals containing higher percentages of volatile matter without the production of excessive amounts of smoke, indicating a large loss, due to incomplete combustion. Aside from the question of furnace design, the primary cause of the high percentages of carbon monoxide was the thickness of the fires. By reducing the thickness from 30 to 12 in. and changing the method of firing, the loss due to this factor was reduced from 14 to 1 per cent., with a corresponding increase in boiler efficiency.

Ashpit Loss

In the operation of a boiler plant a certain percentage of the fuel which is fed to the furnace drops through the grate and is removed from the ashpit. An additional quantity of unburned coal is drawn from the grates in hand-fired plants when the fires are cleaned. If the coal is fine or noncaking and the grates contain large air spaces, excessive amounts of fuel drop into the ashpits. Certain coals clinker badly under some conditions of operation and, therefore, during the removal of this clinker large amounts of unburned coal are drawn from the fires. Another cause of this loss is the frequent barring or raking of the fires when a fine or noncaking coal is used.

The ashpit loss which also includes the combustible removed during cleaning is determined from the weight of this material, the percentage of combustible which it contains together with the weight of the dry coal fired. For the purpose of this computation the heating value of the combustible is taken as 14,600 B.t.u. per lb. In special cases where complete boiler tests are not made and the weights of coal and ashpit refuse are not obtained, the percentage of the heat in the fuel removed with the ashpit refuse and cleanings can be computed from the analysis of this material and the determination of the percentage of ash in the coal as fired. In calculating this item by the latter method the assumption must be made that the percentage of ash obtained by the proximate analysis of the fuel represents the inert matter in the ash and refuse removed from the ashpits and the furnaces; that is, no account is taken of the ash which is carried off the grates and deposited in the combustion chamber, upon the water-heating surface or lost up the stack. A series of tests which indicate the extent to which this loss can be reduced are given in Tests C of Table 1. This plant was equipped with inclined grate stokers upon which Pittsburgh slack coal was burned. The excessive rate at which the fuel was burned to maintain the required capacity caused deterioration of the grates, which allowed large amounts of unburned coal to fall into the ashpits. By careful attention to grate repairs and methods of operating the stokers the boiler efficiency was increased approximately 10 per cent.

Loss Due to Hydrogen

The percentage of hydrogen in various coals is not an indication of their relative value when burned for the generation of steam. The essential feature in determining the effect of this constituent in the process of combustion is the form in which it is available in the furnace. Hydrogen which is driven off in the uncombined state and burned by mixing with the oxygen from the air supply is a valuable factor as it develops about four times the heat generated by an equal percentage of carbon. For the purpose of this discussion the theory of the code of the American Society of Mechanical Engineers for the loss due to hydrogen, is accepted. This theory assumes that all hydrogen contained in the fuel, together with an equivalent amount of oxygen in the form of water is raised from boiler-room temperature, evaporated in the furnace and is eventually superheated to the temperature of the escaping gases. The amount of heat lost in this manner depends upon the composition of the fuel, the temperature of the boiler room and the temperature of the escaping gases. In addition to the loss due to evaporating and superheating the moisture formed by the combustion of hydrogen and by the distillation of oxyhydrogen compounds, a small loss is incurred by subjecting the moisture in the fuel and in the air used for combustion to these processes.

TABLE I. DECREASE OF LOSSES DUE TO FLUE-GAS TEMPERATURE, CARBON MONOXIDE AND UNBURNED FUEL

	Tests A			Tests B			Tests C		
	Original Conditions	Improvement Effected		Original Conditions	Improvement Effected		Original Conditions	Improvement Effected	
1. Loss due to heat carried away by the dry flue gases	35 9	10 0	12.4	15 3	1 1	2.1	13 1	9 1	7 9
2. Loss due to evaporating and superheating moisture in coal and moisture formed by the combustion of hydrogen and distillation of oxyhydrogen compounds	2 7	2.7	2 8	4.1	3 8	4.2	3 2	3.3	3 4
3. Loss due to heat escaping through the formation of carbon monoxide	0 0	0 4	1 6	9.7	15 1	10 7	22 8	19 1	18 2
4. Loss due to combustible removed from the ashpits and from the grate during cleaning	3 2	7 6	4.5	3 2	3.5	3 3	0 0	0.0	0 0
Total determined losses	41 8	20 7	21.3	32 3	23 5	20.3	39 1	31 5	29.5
5. Loss due to unconsumed hydrogen and hydrocarbons, to radiation and unaccounted for (assumed constant for all tests)	8 9	8 9	8.9	11.2	11.2	11.2	7 5	7 5	7 5
6 Approximate percentage of heat absorbed by the boiler or boiler efficiency (by difference)	49.3	70.4	69.8	56.5	65 3	68.5	53 4	61 0	63 0
Total	100.0	100.0	100.0	100 0	100.0	100.0	100.0	100.0	100.0

Increasing interest in the economical operation of boiler plants has resulted in marked improvement in efficiency in the majority of the plants where this matter has been given careful attention. An illustration of the distribution of heat in a boiler plant which was operating with high efficiency before tests were made for contemplated improvement is shown in Table 2. This plant consisted of large units of Climax water-tube boilers

TABLE 2. PLANT OPERATING AT HIGH EFFICIENCY

	Original Coaditions	Improvement Effected	
1. Loss due to evaporating and superheatiog moisture in coal and moisture formed by the combnstion of hydrogen and distillation of oxyhydrogen compouods	4.0	3.8	3.8
2. Loss due to heat carried away by the dry flue gases	14.4	10.1	11.8
3. Loss due to heat escaping through the formation of carbon monoxide	0.9	1.3	0.4
4. Loss due to combustible removed from the ashpits and from the grate dnring cleaning	0.6	0.8	0.9
Total determined losses	19.9	16.0	16.9
5. Loss due to unconsumed hydrogen and hydrocarbons, to radiation and unaccounted for (assumed constant for all tests)	8.0	8.0	8.0
6. Approximate percentage of heat absorbed by the boiler or boiler efficiency (by difference)	72.1	76.0	75.1
Total	100.0	100.0	100.0

equipped with circular grates which were fired through a number of doors. It will be noted from the tabulation that considerable loss, due to the formation of carbon monoxide, occurred, but this waste is more than counterbalanced by the particularly small percentage of combustible removed from the ashpits and furnaces. The amount of combustible in this material averaged about 12 to 15 per cent., representing a fuel loss of from 0.5 to 1 per cent. Although the operating conditions in this plant were excellent, still greater care in the methods of firing effected an increase in boiler efficiency.

Mexican Boiler Explosion

By T. E. Dutton

The accompanying photographs show the results of a recent boiler explosion in Mexico. There were four 125-hp. fire-tube boilers in a row, and a smaller one behind them. One of the center boilers exploded, demolishing the setting of all the boilers. The exploded boiler was thrown forward about 50 ft. It was made with two sections and the front plate tore away from the rear plate, shearing nearly all of the rivets on the girth seam. The front plate, which failed, ripped along over the fire. It was found badly corroded and extremely thin in places, which was no doubt the cause of the explosion.

One fireman was killed and another injured. The accident happened at night and but few men were about.

Even a superficial inspection would have exposed the state of the boiler, but boiler inspectors are an unknown quantity down here in Mexico.

Settled Ten Feet but Kept on Running

By T. Peacock

If a stationary engine on a stone or concrete foundation were out of level by the fractional part of an inch, most engineers would consider that leveling up would be highly essential for safe operation. The following instance shows what can be done in case of necessity, and the circumstances are probably without parallel.

The case referred to is that of a compressor used for furnishing blast to copper converters at the United Verde Copper Co.'s smelter at Jerome, Arizona. It is a cross-compound engine with duplex air cylinders, built by the Southwark Foundry & Machine Co. in 1902. The steam cylinders are 28- and 52-in. diameter by 60-in. stroke, while the air cylinders were originally 96-in. diameter.

In November, 1910, the air cylinders were changed to 60 in. At that time the engine was slightly out of level, but it was urgently needed, and there was no time to level it up. The cause of the engine being out of level was the subsidence of old mine workings under the power house, and several other large blowing engines and compressors were also more or less out of level. The Southwark engine was got ready for work in January, 1911, and was put on continuous 24-hour service.

Shortly after the engine was started the subsidence of the power house increased to an alarming extent, the concrete floor and walls of the building cracking in several places. A boiler room containing 16 Scotch marine boilers stood next to the power house and the caving area extended under the boilers, causing considerable trouble from leaking steam pipes and connections.

It was then decided to move the whole of the machinery and boilers from the area of subsidence to a new site as quickly as possible. New air compressors for the mine, driven by electric motors, furnished with power from a hydroelectric power plant were installed and it was only necessary to set up 10 of the Scotch boilers. These were

Result of a Return-Tubular Boiler Explosion in Mexico

ioved to safe foundations, along with two Allis blowing igines for converter work. A new steam turbine-driven rbo-blower large enough to furnish blast for all the nverters was ordered. Meanwhile another large Nord-erg blowing engine was wrecked by the subsidence, and was necessary to keep the Southwark blowing engine nning constantly at a reduced speed, in conjunction ith the Allis engines, in order to furnish sufficient blast keep the smelter going at two-thirds of its capacity.

The Southwark engine was run steadily until March 3 of this year, when the new turbo-blower was put in peration, and it was kept in running order until April 7, when the work of moving it to a new foundation as begun. It was run for a short time as late as April, 2, and during several months it was stopped only occa-onally for a few hours to lengthen the steam, exhaust, air-discharge pipes between the point of suspension on ie roof of the power house and the engine, as the sub-dence under the engine was greater than under the alls of the building, necessitating swing joints in the ipes to take care of the constantly increasing distance etween the main pipes and the engine, in addition to ie occasional insertion of 12 or 15 in. in each pipe.

The photograph was taken on April 16, 1912, the day efore the engine was dismantled for removal. The white ne is a chalk line exactly level and set two feet below ie original level of the floor.

ENGINE STILL RUNNING AFTER SETTLING FROM A LEVEL 2 FT. ABOVE THE CHALK LINE

The length of the engine is 41 ft. 9 in. from end to nd of the bedplate, the width overall of the two bed-lates being 19 ft. 6 in.

The crank end of the foundation had sunk 5 ft. 1 n. and the cylinder end was 9 ft. 9 in. below the origi-al level, the difference in level over the length of the ngine being 4 ft. 8 in. The shaft was 3 in. out of level, hile the piston rods of the air cylinders were only ¾ of n inch different in level, the low-pressure steam side eing down in both cases.

The engine foundation was one solid block of masonry with concrete top, the only opening in the foundation being a narrow pit for the flywheel. It is probably due to this solid form of foundation that the engine was kept running under such extraordinary conditions, as all the other engines in the same power house had separate foundations under each side of the engine, and most of them moved out of parallel during the subsidence, either by the separate foundations coming together or moving apart, a result which experience showed could not be prevented by any amount of timber struts or tie-rods.

Large Shipment of Blowing Engines

The Mesta Machine Co., Pittsburgh, Penn., has just made a shipment of three large blast-furnace blowing engines, built for the Broken Hill Proprietary Co., Ltd., Melbourne, Australia. These engines are of the vertical high-speed type and will be used in connection with a new blast-furnace plant, which will make the first pig-iron produced in Australia.

Two of the engines are for high-pressure steam with 44-in. steam cylinders, 60-in. stroke and 84-in. air cylinders. The other engine is for low-pressure steam with an 84-in. steam cylinder, 60-in. stroke and an 84-in. air cylinder. All air heads are equipped with the Mesta plate valves, of the Iversen patent.

Twenty-three cars were required to carry this shipment, the total weight being about 1,300,000 lb. The shipment was hauled in one train to New York in 24 hr. from the time it left the yards at Pittsburgh. From New York the shipment will be taken by the American-Australian line around the Horn to Australia, the total distance being about 8000 miles and requiring about 70 days to make the journey.

Situation for Dynamo Tender—The United States Civil Service Commission announces an open examination for dynamo tender, on Sept. 17, 1913, to fill a vacancy in the immigration Service at Ellis Island, New York, at a salary of $900 a year. The examination will include letter writing, practical questions relating to the principles of construction and operation of dynamos and training and experience. This examination is open to all men who are citizens of the United States and 20 or more years of age. Further particulars may be obtained by addressing the United States Civil Service Commission, Washington, D. C.

The Possibilities of Locomotive Fuel Economy have been under investigation on the St. Louis & San Francisco R.R. for the last two years. In a paper presented before the St. Louis Railway Club recently by R. Collett, superintendent of locomotive fuel service for this railroad company, a chart was shown which indicated the results obtained by comparing the coal consumption in pounds per passenger-car mile and in pounds per thousand-gross-ton mile for corresponding months in 1910, 1911 and 1912. A material reduction was effected in 1911, and this was virtually retained in 1912 in spite of floods, severe weather, suspension of mines and other unfavorable operating conditions occurring during 1912, making it more difficult for the past year to show improvement.

ELECTRICAL DEPARTMENT

New Line of Portable Meters

The Westinghouse Electric & Mfg. Co. has just introduced a new line of direct-reading instruments for general testing and laboratory work where special accuracy is desired, particularly in alternating-current work. The type PC voltmeters and wattmeters operate on the moving coil principle, and the damped character of the indications permits readings to be taken quickly and accurately, which is desirable in fluctuating loads.

The movement is mounted as a unit and can be removed complete after taking off the face-plate, which makes a dust-proof joint with an inner aluminum mounting plate. The meters have a laminated iron shield riveted to the aluminum mounting plate, protecting the movement both from dust and from stray magnetic fields. The weight of the moving element is in all cases low,

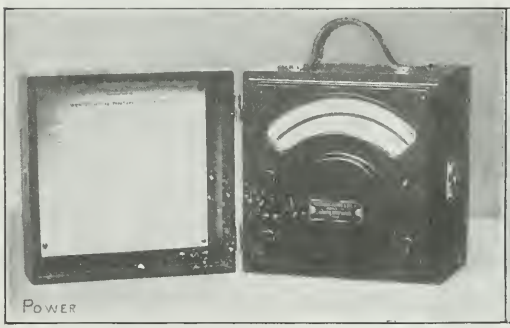


FIG. 1. INSTRUMENT WITH FACEPLATE IN PLACE

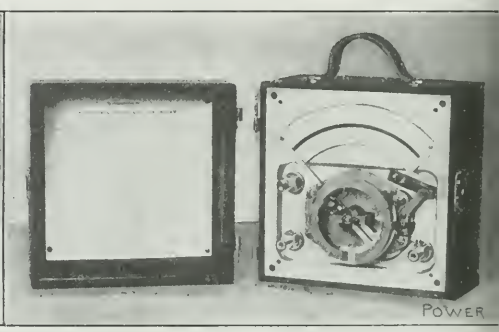


FIG. 2. INSTRUMENT WITH FACEPLATE REMOVED

preserving the pivot jewels from wear, and the torque is relatively high. The pointer is of U section, to secure strength with minimum weight; the weight of the moving element is less than 5 gr.

The meters attain their highest accuracy on alternating current, and are claimed to be free from temperature, frequency and wave-shape errors. On direct current, the meter may be subject to slight errors due to residual magnetism of the laminated iron shield, but this can be eliminated by taking the average of reversed readings.

The wattmeters are also entirely self-contained, all resistors necessary for the rated-voltage ranges being contained in the case. Those that have double current or double-voltage ranges are provided with a switch operated by a knob on the face-plate, which makes the proper series or series-parallel connection of coils when the knob is turned to the proper position. Only two current and two voltage binding-posts are, therefore, necessary

The scale for the wattmeters is wider at the lower end to give greater accuracy for the low readings, and for the voltmeters it is wider at the middle, where readings are most frequently made. A mirror extending the entire length of the scale prevents parallax in reading.

New York Electrical Show

The Electrical Exposition and Motor Show to b opened at the Grand Central Palace in New York o Oct. 15 is to be primarily of an educational nature i relation to the use of electricity in manufacturing. Th motor vehicle will be given a more prominent place tha ever, and arrangements have been made to devote almos an entire floor to the electric automobile manufacture Besides the usual demonstration track, a fireproof mod garage for the storing and maintenance of electric ca will be located on the third floor. The garage will b fully equipped with electrical vacuum cleaners, tir pumps, car-washing machines, charging boards, and cu rent rectifiers, and will include a repair shop and bat tery, each fitted out with the latest electrical appliance

Another feature of the show will be an "electric farm, occupying ninety feet or more of show space and includ ing every kind of farm work into which electricity ha been introduced. First of all will come the cow-milkin exhibit. Here members of a herd of Jersey cows wil be milked by an electrically operated milking machin and milk clarifier. The next exhibit will probably b that of an electrical dairy, where the milk will b skimmed and butter actually churned from the crea procured.

As a part of the farm exhibition a part of the space will be turned over to a landscape gardener, who wil construct a miniature farm with an artificial duck pond Here chickens and ducks will be hatched in electric incu bators. Next will come an exhibition of electrical ap pliances used on a farm such as house and well pumps clover cutters, corn shellers, cider mills, vegetable cutter for cattle, ensilage cutters and blowers, electrical clipping machines, vacuum-cleaning outfits and the like.

Two interesting canal displays have been arranged one, provided by the State of New York, is a large mod of the Siphon Locks on the Barge Canal. In connectio with this, motion pictures of the canal in use will prob bly be displayed. The other canal exhibit is a 20x4-f

model of the Pedro Miguel Locks of the Panama Canal. The model is now in the White House.

There are a variety of Government exhibitions, including a money-making exhibit, provided by the Treasury Department; a coal-mine breaker in action, provided by the Bureau of Mines; a forestry display and an Army and Navy Signal-Service outfit. In the first-mentioned exhibition raw copper will be started through the same process used in the United States mint, the operations showing the method of rolling, cutting, milling, annealing in a furnace, washing, drying, coining and automatic weighing.

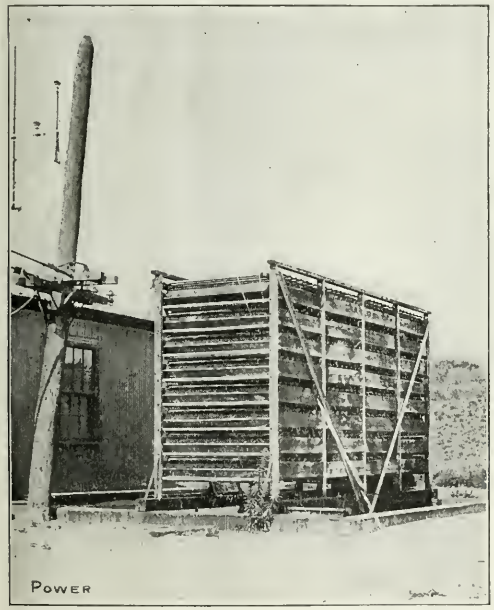
Two of the newest features of the show will be an electrical clinic, where all of the latest electro-therapeutic appliances will be on display.

Another interesting portion of the show will be the electric grill, where electricity will be used to do everything from operating the refrigerating plant to furnishing the heat in the range on which steaks and chops are grilled.

Saving Water in a Large Substation

By H. S. Knowlton

In a substation operated by a hydro-electric power company and containing six 1500-kw. transformers reducing the line voltage from 66,000 to 13,200, the cost of cooling water for the transformers was found to be excessive.



Cooling Tower for Transformer Circulating Water

The efficiency of the modern transformer is high, running from 97 to 98 per cent. in many cases, but even this slight loss means that from 180 to 270 kw. must be dissipated in heat generated in the windings and cases of such an installation as the above. A continuous supply of cooling water circulating through pipe coils in the transformer is therefore necessary and in the operation of such substations the greatest care is taken to watch the temperature of the supply and discharge piping interiors, in order that there shall be no sudden rise in the heating effect and consequent damage to the apparatus.

In this installation the cost of city water was cut down to a small fraction of the former expense by the construction of the homemade cooling tower shown in the photograph. The hot water from the transformer coils is piped to the top of this structure and allowed to trickle down over sets of wooden racks and shelves, open to air currents and into a concrete catch basin at the bottom, from which it is forced back to the transformers by duplicate motor-driven centrifugal pumps. The evaporation has to be made up from the city mains, but a large part of the water is used over and over with substantial economy. Cooling towers are often used in steam plants, but their possibilities in electric-substation service are only beginning to be realized.

Care of Brushes

Most instructions on the care of brushes of dynamos or motors state that one should draw a piece of sandpaper back and forth over the commutator, with the sanded side against the brush.

Just why it should be drawn back and forth, the writer could never understand, since in most brush-holders, with the exception of copper brushes, there is always a certain clearance between the brush and the holder in order to make the brush slide easily up and down and make sure contact with the commutator. Giving the matter a little thought it is easy to see that drawing the sandpaper back and forth will cause the brush to rock in the holder and thus make a loose fit between the brush and the commutator.

In the writer's opinion the sandpaper should be drawn in the direction of rotation of the commutator with a pressure on top of the brush and slightly against the rotation of the commutator. In no case should the sandpaper be drawn against the direction of rotation with pressure on the brush; on the back stroke the brush should be lifted clear of the commutator. This will make the brush fit exactly on the commutator and save considerable sparking and heating of the commutator, to say nothing of wearing grooves in it, especially when the brushes are rather hard.

Frank Garthmann.

Milwaukee, Wis.

Electrical Power Consumed in Chicago

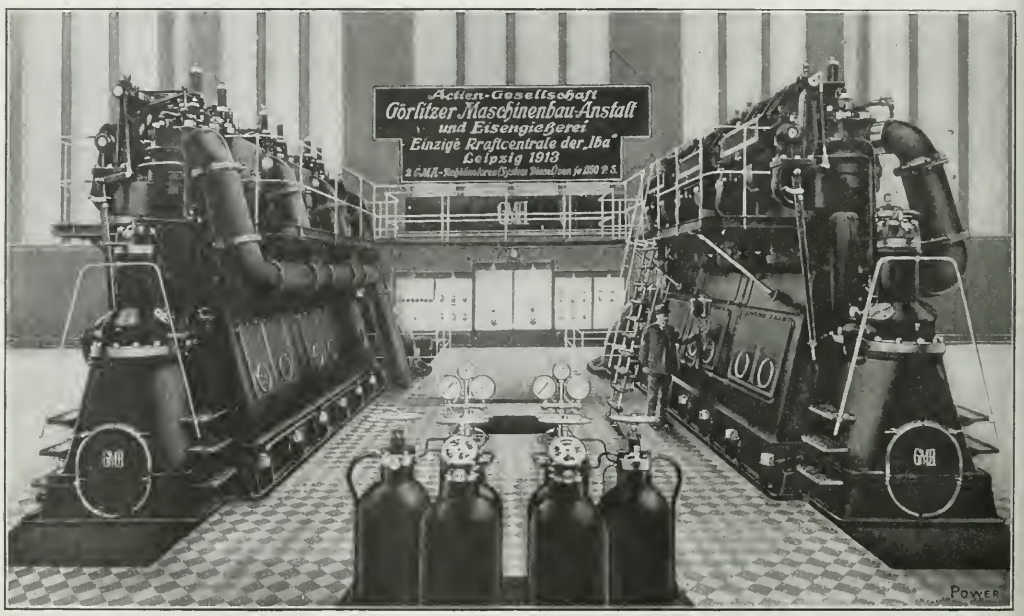
Chicago leads the world in the production of electric power. The output of 303 electric-supply undertakings in Great Britain for the year 1911-12 amounted to 1,127,499,742 units, but Chicago by itself has an annual output of over 800,000,000, and expects within a year to turn out a billion. The Chicago Commonwealth Edison Co. generates more current than the local Edison companies of New York, Philadelphia, Brooklyn and Boston combined. The Eastern companies, however, do not supply power for local transportation, while the Chicago company does. The latter operates the largest single electric-power-generating plant in the world and its price for its product is said to be lower than that of any other electric power-vending company in the world.

GAS POWER DEPARTMENT

Oil-Motor Power at Leipzig Building Exposition

By Dr. Alfred Gradenwitz

In the huge engine hall of the Leipzig International Building Exposition, two large crude-oil motors, exhibited by Messrs. Görlitzer Maschinenbau-Anstalt, Ltd., of Görlitz, aroused general interest among all visitors. These two motors are coupled directly to dynamos which supply all the electricity for light and power at the exposition.



Diesel Engines at Leipzig Exposition

The engines are of the vertical type and are arranged to work on the single-acting four-stroke-cycle Diesel principle. With a view to a satisfactory balancing of the masses, smooth running and easy starting, they are designed in six-cylinder arrangement, each engine developing 1150 b.hp. at 167 r.p.m.

A special feature of these engines is the box-shaped frame with which the cylinder jackets are cast integral. Moreover, the cylinders are cast in pairs. This design ensures a simple and compact arrangement, and the casting together of the cylinders in pairs dispenses with three bearings.

The valve gear of all the cylinders is mounted on a subdivided shaft, the bearings of which are fixed, not to the cylinder covers, but to the camshaft brackets. Therefore, in removing the valves there is no need for dismounting the valve-gear shaft, this being simply moved aside.

Each group of three fuel pumps is contained in a common casing, so that there are two pump casings for each engine, arranged jointly on one side of the engine near the governor and driven in common by a single eccentric mounted on the camshaft. Governing is effected by altering the suction-valve closure of the pumps, so as to control the fuel supply.

The single-acting double-stage vertical air pump is arranged at the side of the motor, the pump casing being fitted into the cooling water compartment of the motor frame. The pump is actuated by a crank drive from the main shaft.

The method of starting these engines is unusual, only two cylinders being used for this purpose. To this effect the lever shaft has been subdivided, only starting levers being included in the part corresponding to the two starting cylinders.

Ample water cooling of all vital parts, such as the cylinder covers, working cylinders, air-pump cylinders, etc., has been provided for. The main-shaft bearings likewise are water cooled. Lubrication of all important parts is effected from a central lubricator.

The engines are designed to operate on either mineral oils or coal-tar oils.

Time of Ignition vs. Economy

By A. B. Morrison, Jr.

To get the maximum effects on light loads, where the compression is lower and the mixture poorer, it is necessary to have the ignition occur considerably earlier than on heavier loads. Just how much this can affect the general behavior of the engine is not generally appreciated. With the usual type of stationary engine it is not possible nor practicable to change the point of ignition to correspond to the load being carried. The latter may vary between wide ranges in such a short time that with a manually changed point of ignition the operator is unable to vary it quickly enough to correspond to the load. If, however, the ignition is automatically controlled by the governor, it can be advanced or retarded according to the load.

In order to demonstrate the difference between an engine with the ignition fixed at the same point in the stroke for all loads and one in which the ignition is automatically varied by the governor, the writer some years ago ran a series of tests, the results of which are shown in the accompanying curves. The engine was of the three-cylinder vertical type, equipped with a throttling governor and make-and-break ignition and was operated on natural gas. The time at which the igniter dropped was controlled by means of a lever connected to a collar on the governor, this lever acting on the ignition camshaft and advancing the point of ignition as the load decreased and retarding it on the heavier loads. A series of tests was run, with the governor operating in this manner, at various loads, obtained by means of a prony brake. The data secured are shown by the curves marked "I," which give the total gas per hour and the cubic feet of gas consumed per brake horsepower-hour.

A second set of readings was then taken with the same loads as in the first, but with the variable-ignition feature omitted, the igniter dropping at the same point at all loads. In making this second test the maximum load was taken at a point corresponding to 115 per cent. of the manufacturer's rating and the ignition was adjusted until an indicator diagram taken with this load showed an ignition line practically vertical. An earlier ignition would have caused the engine to knock at this maximum load. It was assumed that the engine would never be called upon to carry a load in excess of this assumed maximum. The results of the second test are shown by the curves marked "II."

An analysis of the two sets of curves shows the following:

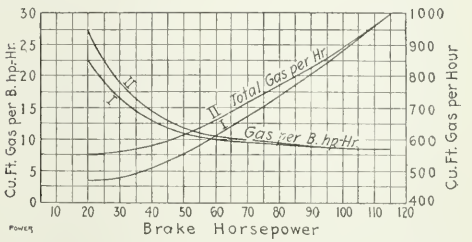
1. Between three-quarter and maximum load there is little difference in the fuel economy, whether fixed or variable ignition is used.

2. Between three-quarters and one-half load there is a considerable difference and below one-half load a very marked difference in favor of the variable ignition. Assuming the rated load of the engine to be 100 hp. (which is the manufacturer's rating), the difference at three-quarters load is approximately 4½ per cent., at one-half load, 10 per cent., and at one-quarter load, 16 per cent.

3. If the engine is designed to carry an overload in excess of the rating, and if fixed ignition is used, it should be set at a point corresponding to the maximum load which the engine will be called upon to meet. To obtain good economies on light loads, however, the ignition point at maximum load will be too early for best operating results at this maximum.

It is apparent from the curves that where an engine is operating on a load which varies widely during short intervals and with a fuel of practically constant heat value, the point of ignition automatically controlled by the governor, shows a very marked increase in fuel economy. While not apparent from the curves, the behavior of the engine at loads below 50 per cent. of the rating was much better with the variable than with the fixed ignition; the speed regulation was closer and there was no tendency to backfire, whereas, with fixed ignition, the engine was inclined to race and there were occasional backfires, though these were not pronounced.

The foregoing facts regarding fuel economy hold only with a gas of practically constant composition, such as natural or illuminating gas. Where producer gas is used, and especially with a suction producer, the variable ignition feature should not be used as it is usually a detriment instead of a benefit. This is because with a producer the gas is not likely to be even approximately uniform in quality and on light loads is usually leaner than on heavier loads. In order to obtain the same horsepower from the engine with the poorer gas more must be taken into the cylinders and the ignition must be made earlier, as the flame propagation with the poorer gas is decidedly slower. Therefore, if the engine is equipped with variable ignition and the load is suddenly increased, the governor admits more of the mixture and in so doing automatically retards the ignition. If the gas happens to be poorer than normal, which is almost invariably the case if the producer has been on light load for some time, the action of the governor in retarding the ignition is exactly opposite to what should occur, for as shown above, the poorer gas requires advancing the ignition point instead of retarding it. The result is that the maximum power is not developed from the charge and more mixture is admitted, still further retarding the ignition. The net result is an actual loss in economy and power instead of a gain. With fixed ignition this trouble does not occur to such an extent. Variable ignition controlled by the governor has been used on producer engines, but has been, in almost every case, changed to fixed ignition. The igniter is set to give the best results on about the average load, with due regard to the maximum load which the engine may be called upon to handle.



Comparison of Fuel Consumption with Fixed and Variable Ignition

REFRIGERATION DEPARTMENT

Mollier Diagram for Ammonia*

To facilitate the solution of refrigeration problems, a heat content-entropy diagram was prepared by the authors of the bulletin, and is presented herewith. This diagram has two families of curves: (a) curves of constant pressure, and (b) curves of constant quality in the saturated region and constant temperature in the region of superheat. The ordinates are heat contents; the abscissas are entropies.

To use as large scales as possible and at the same time to bring the diagram into reasonable compass oblique coordinates have been used. The axis of ordinates instead of being vertical is inclined to the left at an angle of 30 deg. with the axis of abscissas. Taking the values of entropy along the horizontal axis, values of heat content may be taken either along the inclined axis or along a vertical axis. Since vertical distances are equal to distances along the oblique axis multiplied by the sine of 30 deg., the scale for measuring heat contents along the oblique lines is such that a distance measured along the 30-deg. lines represents sine 30 deg. (or ½) times as many units of heat content as are represented by the same distance measured vertically.

The 30 deg. lines are lines of constant entropy and show the change of condition of the ammonia during adiabatic compression or expansion. Measurements along these lines give the change in heat content during adiabatic compression or expansion. Horizontal lines are lines of constant heat content; they show the change in condition of the ammonia which results from a throttling process, such as the passage through the expansion valve of a refrigerating machine.

The lines of constant pressure after meeting the liquid line should be extended beyond this line to the left to represent the cooling of the liquid at constant pressure below the temperature of saturation for that pressure. The constant pressure lines are so nearly tangent to the liquid line that the several lines could not be distinguished with the scale employed. The process of cooling the liquid below saturation temperature is therefore represented for all pressures by the liquid line itself.

The following examples will illustrate the method of solution of some of the more commonly occurring problems.

Work Done in the Compressor Assuming the Rankine Ideal Cycle

In the Rankine cycle, the ammonia is admitted at a constant pressure, is compressed adiabatically to the discharge pressure, and is discharged against this constant pressure. The compressor is supposed to have no clearance. The cycle is ideal with no internal friction, no heat losses and no free or imperfectly resisted expansion. In such a cycle the work done per pound of ammonia is the difference in heat content at the beginning and end of compression. As the only compression that takes place is adiabatic, the ammonia leaving has the same entropy as that entering.

To find the work done upon one pound of ammonia, in a Rankine cycle admitting ammonia at a known quality and pressure, and compressing it to a known discharge pressure, locate the point representing the quality and pressure of the suction ammonia, and measure the distance upward to the left along a 30-deg. line to the discharge pressure line. If the quality and pressure at discharge and the suction pressure only are known, locate the point representing the quality and pressure of the discharge ammonia, and measure the distance downward to the right along a 30-deg. line to the suction pressure line. In either case the distance represents the work done in B.t.u.

Example 1. In a dry compression system, ammonia, initially dry and saturated at a pressure of 25 lb. per sq.in. abs., goes through a Rankine cycle in which it is compressed to a pressure of 200 lb. per sq.in. abs. How much work is done on each pound of ammonia?

The heat content of dry and saturated ammonia at a pressure of 25 lb. is seen from the diagram to be 536 B.t.u. Ammonia of the same entropy at 200 lb. pressure has a temperature of 271 deg. F. and has a heat content of 671 B.t.u. The work of the Rankine cycle is

$$536 - 671 = -135 \ B.t.u.,$$

the minus sign signifying work done on the ammonia. The same value is obtained with twice as great accuracy by measuring the distance along the 30-deg. line between the points representing the initial and final states of the ammonia.

Example 2. In a wet compression system, ammonia, after having gone through a Rankine cycle with a suction pressure of 25 lb., is discharged dry and saturated at a pressure of 200 lb. How much work is done on each pound of ammonia?

The heat content of dry and saturated ammonia at a pressure of 200 lb. is seen to be 560 B.t.u. Ammonia of the same entropy at 25 lb. pressure has a quality of 0.86 and has a heat content of 457 B.t.u. The work of the Rankine cycle is

$$457 - 560 = -103 \ B.t.u.$$

Heat Rejected by Ammonia in Condenser and Cooler

To find the heat rejected per pound of ammonia in the condenser and cooler, locate the point representing the state of the ammonia after compression, and pass down a constant pressure curve to the point representing the state of the ammonia before the expansion valve. The vertical distance passed through, that is the difference between the heat contents at the initial and final states, gives the heat rejected to the cooling water per pound of ammonia. Part of this heat is taken out as the superheat, if any, is removed; the greater part is

*From Bulletin 66 of the University of Illinois Engineering Experiment Station. Authors, G. A. Goodenough and W. E. Mosher.

ken out as the ammonia is condensed; and the re- inder is taken out as the liquid is cooled from the mperature of saturation at the given pressure to the mperature before the expansion valve; this latter part ually takes place in a cooler separate from the con- nser.

Example 3. Ammonia, after being compressed as in ample 1 to a pressure of 200 lb. and a temperature 271 deg. F., is passed through the cooler and condenser d when it reaches the expansion valve has a tempera- re of 80 deg. F. How much heat is rejected to the oling water?

The heat content after compression was found in Ex- mple 1 to be 671 B.t.u. Passing down the constant essure line the superheat is removed, the ammonia ndensed, and the liquid cooled from saturation tempera- re of 96 to 80 deg. F. At the latter point the heat ntent is seen from the diagram to be 54 B.t.u. The at rejected to the cooling water is

$$671 - 54 = 617 \ B.t.u.$$

Example 4. Find the heat rejected to the cooling ater if the ammonia compressed as in Example 2 to a y and saturated state at 200 lb. pressure is cooled to a mperature of 80 deg. F. before the expansion valve.

By a process similar to that given in Example 3, the at rejected to the cooling water is

$$560 - 54 = 506 \ B.t.u.$$

Throttling through the Expansion Valve

If vapor is allowed to expand through a small orifice, uch as the expansion valve, without the addition or bstraction of heat, and is finally brought to its initial elocity, its heat content will be unchanged. The proof f this statement is based on the thermodynamic theory f flow of liquids and may be found in any standard text. Horizontal lines on the diagram are lines of constant eat content and consequently show the changes in the ondition of the ammonia which result from throttling n the expansion valve.

Example 5. Liquid ammonia in front of the expan- ion valve has a temperature of 80 deg. F., and after pass- ng through the valve the pressure of the mixture of apor and liquid is 25 lb. What is the quality of the nixture?

The horizontal line which intersects the liquid line at temperature of 80 deg. F., intersects the 25 lb. pressure ine at a point which is found by interpolation to corre- pond to a quality of 0.16. This horizontal line repre- ents a constant heat content of 54 B.t.u.

Refrigerating Effect

The refrigerating effect is measured directly by the hange in i (the heat content at constant pressure) which he ammonia undergoes during evaporation, this being a constant pressure process in which, as shown above, the ncrease in i is equal to the heat absorbed.

To find the refrigerating effect per pound of ammonia, ocate the point representing the state of the ammonia fter its passage through the expansion valve, and pass up along a constant pressure line to the point represent- ing the state of the ammonia at the beginning of com- pression. The vertical distance passed through, that is the difference between the heat contents at the initial and final states, gives the refrigerating effect per pound of ammonia.

Example 6. After being throttled through the expan- sion valve to a pressure of 25 lb. and a quality of 0.16, the ammonia evaporates in the refrigerating coils until it is just dry and saturated at this pressure. What is the refrigerating effect per pound of ammonia circulated?

From the diagram the change in i, or the heat absorbed by the ammonia is

$$536 - 54 = 482 \ B.t.u.$$

Example 7. Find the refrigerating effect per pound of ammonia when the condition after the expansion valve is the same as in Example 6, but evaporation takes place as in the wet compression system of Example 2 only until a quality of 0.86 is reached.

From the chart the refrigerating effect is

$$457 - 54 = 403 \ B.t.u.$$

Thoretical Coefficient of Performance and Refrigerating Effect per Horsepower-hour

By definition the coefficient of performance is equal to the ratio of the heat absorbed by the refrigerating medium to the work done upon it. It has been shown that both of these quantities can be read from the diagram, and therefore the coefficient of performance can be calculated for any assumed conditions of operation.

Example 8. What is the coefficient of performance of the dry compression process of Examples 1, 3, 5 and 6?

From Example 6 the heat absorbed is 482 B.t.u., and from Example 1 the work done on the ammonia is 135 B.t.u. The coefficient of performance is therefore

$$482 \div 135 = 3.57.$$

Since one horsepower-hour is equal to 2546 B.t.u., the refrigerating effect per horsepower-hour is

$$2546 \times 3.57 = 9090 \ B.t.u.$$

Example 9. What is the coefficient of performance of the wet compression system of examples 2, 4, 5 and 7?

From Example 7 the heat absorbed is 403 B.t.u., and from Example 2 the work done on the ammonia is 103 B.t.u. The coefficient of performance is therefore

$$403 \div 103 = 3.91.$$

The refrigerating effect per horsepower-hour is

$$2546 \times 3.91 = 9960 \ B.t.u.$$

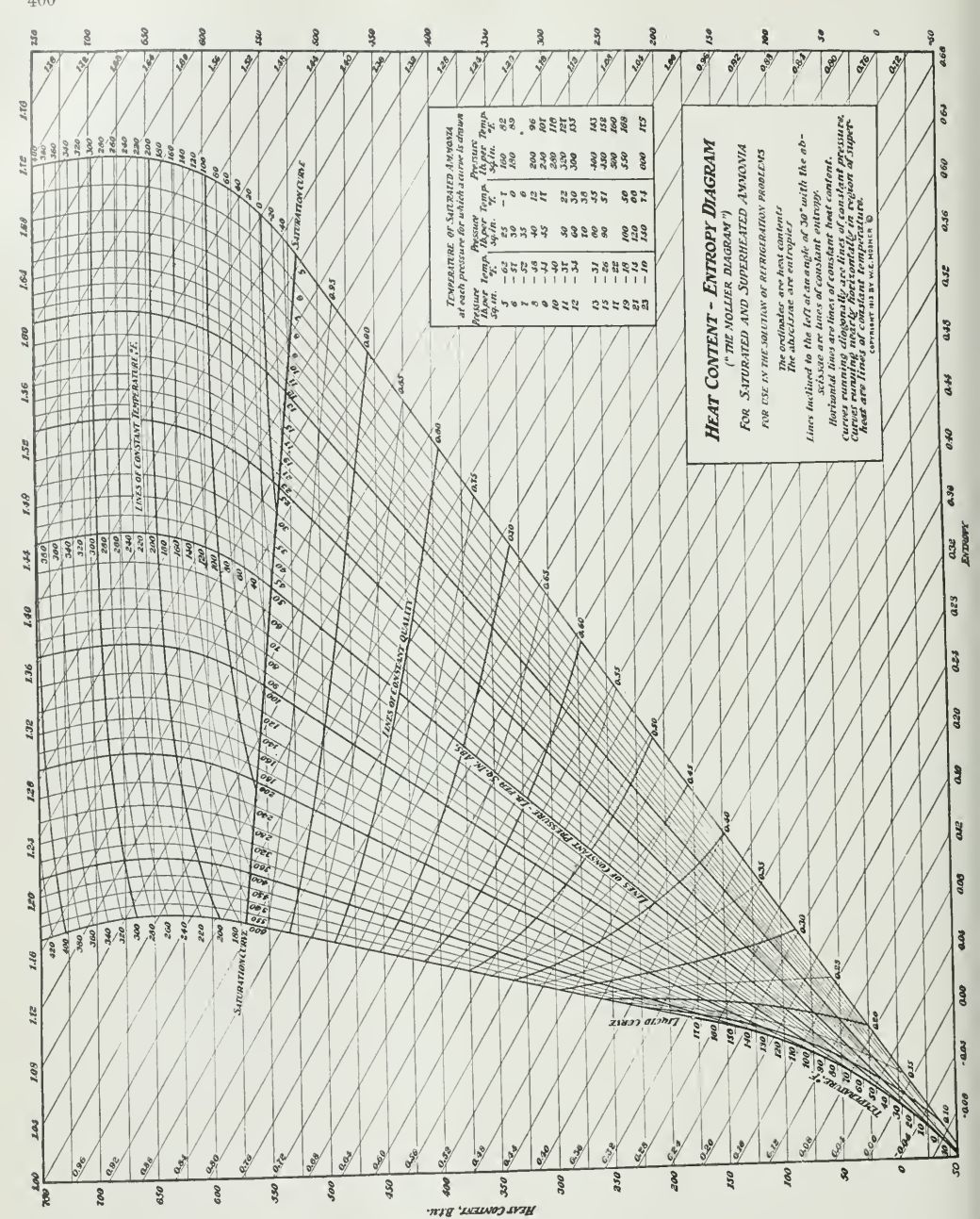
From the above examples it is seen that the theoretical loss with dry compression as compared with wet compression under these conditions is

$$\frac{9960 - 9090}{9960} = 8.7 \ per \ cent.$$

Saving Possible by Use of Expansion Cylinder

If instead of the expansion valve an expansion cylinder were used the irreversible throttling process would be replaced by a reversible adiabatic expansion. In that case the reduction of pressure instead of being represented on the diagram by a horizontal line extending from the point representing the state before the expansion valve to the refrigerator pressure line, would be represented by an adiabatic. The length of this adiabatic would measure in heat units the work recovered by the use of the expansion cylinder and the gain in refrigerating effect would be measured by the change in i along the adiabatic.

Example 10. Find the per cent. gain due to substituting an expansion cylinder for the expansion valve in the wet compression system described in Examples 2, 4, 5 and 7.


HEAT CONTENT - ENTROPY DIAGRAM
("THE MOLLIER DIAGRAM")
FOR SATURATED AND SUPERHEATED AMMONIA
FOR USE IN THE SOLUTION OF REFRIGERATION PROBLEMS
The ordinates are heat contents
The abscissæ are entropy
Lines inclined to the left at an angle of 30° with the abscissæ are lines of constant heat content.
Horizontal lines are lines of constant pressure.
Curves running nearly horizontally in region of superheat are lines of constant temperature.
Constructed by W. E. Mollier
TEMPERATURE OF SATURATED AMMONIA at each press. per sq. in. above & below atmos.
Vacuum, In. Hg. | Vapor Temp. °F. | Pressure Lb. per Sq. In. | Vapor Temp. °F.
3 | 62 | 25 | 22
6 | 47 | 30 | 32
7 | 42 | 35 | 40
8 | 36 | 40 | 48
9 | 31 | 45 | 55
10 | 25 | 50 | 62
11 | 19 | 60 | 72
12 | 13 | 70 | 81
13 | 7 | 80 | 88
14 | 1 | 90 | 96
15 | — 5 | 100 | 101
16 | — 11 | 110 | 107
17 | — 17 | 120 | 113
18 | — 22 | 130 | 118
19 | — 28 | 140 | 123
20 | — 34 | 150 | 128
21 | — 40 | 160 | 132
22 | — 46 | 170 | 136
23 | — 51 | 180 | 140
190 | 144
200 | 148
210 | 151
220 | 155
230 | 158
240 | 161
250 | 164
260 | 167
270 | 170
280 | 173
290 | 176
300 | 179
310 | 181
320 | 184
330 | 187
340 | 189
350 | 192
360 | 194
370 | 197
380 | 199
390 | 201
400 | 204
410 | 206
420 | 208
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440 | 212
450 | 214
460 | 216
470 | 218
480 | 220
490 | 222
500 | 224
510 | 226
520 | 228
530 | 230
540 | 232
550 | 234
560 | 236
570 | 238
580 | 240
590 | 242
600 | 244
610 | 246
620 | 248
630 | 250
640 | 252
650 | 254
660 | 256
670 | 258
680 | 260
690 | 262
700 | 264
SATURATION CURVE
LINES OF CONSTANT TEMPERATURE, °F.
LINES OF CONSTANT QUALITY
LINES OF CONSTANT PRESSURE - LB. PER SQ. IN. ABS.
LIQUID CURVE
TEMPERATURE, °F.
HEAT CONTENT, B.t.u.
ENTROPY

The work of compression would be the same as in Example 2, or 103 B.t.u. The heat rejected to the cooling water would be the same as in Example 4, or 506 *B.t.u.* The expansion in the expansion cylinder would be represented by a 30-deg. adiabatic extending from the point representing liquid at a temperature of 80 deg. F. downward to the 25 lb. pressure line. The length of this line gives the work obtained in the expansion cylinder, assuming a Rankine cycle, or 9 B.t.u. The refrigerating effect would be increased by 54 — 45 = 9 *B.t.u.* The coefficient of performance would therefore be

$$(403 + 9) \div (103 - 9) = 4.38.$$

The per cent gain from the expansion cylinder is

$$(4.38 - 3.91) \div 3.91 = 12 \textit{ per cent.}$$

EDITORIALS

Co-operation between Isolated Plants and the Central Station

Percival R. Moses, of New York, suggested in the *Engineering Magazine* last winter that the isolated plant might help out the central station at times of overload. An industrial plant need not shut down as soon as its employees stop working, but could keep on running and furnish to the distributing mains the current necessary to get them home on the tramway and to light their dinner tables, avoiding the necessity for the installation by the central station of extra plant to carry the peak which would otherwise be produced. The idea found favor in the eyes of an unknown writer, who made it the subject of an article entitled "Coöperation between Private and Public Supply Systems," in the *Electrical Review* (London) of March 28. In the August 22 issue of the same paper Douglas S. Martin points out that Moses is the apostle of the isolated plant, and takes the unknown writer severely to task for "falling to him" so easily.

Douglas S. Martin is not the apostle of the isolated plant. He would mix all the demands together so as to get the advantage of their diversity in time of demand, and then let the central station supply them all in order that it may profit by that diversity. "There is no place for the small plant," he says, "in this scheme of balance and mutual power flow, and *every small plant must go* in order to provide all the diversity for the main station which can possibly be obtained."

Diversity of demand is a good thing—enough of it will iron out all the protuberances in the load line. A comparatively small investment takes care of many maxima when they do not overlap. But the purchaser should share in the advantage. The standing charges urged in making the rate should be those on the plant actually required to meet the diversity of demand and not upon the plant which would be required to meet these demands if they were superposed, as is the case when the rate to each consumer is based upon his own maximum demand.

The load density may become so great in a given locality as to make it advisable to erect an auxiliary station to care for it. "When the auxiliary station is built and put into operation," says Mr. Martin, "it must be a big station in order that its efficiency may be high and 'industrial waste eliminated,' and it must be given as high a diversity factor as possible. To that end every isolated plant in that locality must go out of business."

If these isolated plants, so ruthlessly condemned, would be running at the time the central station is on its peak, it would not tend to flatten its peak to take them over. If they would not be running on their own load at that time, why could they not profitably be used to pump current into the mains and relieve the central station of a part of its embarrassing overload? They might not like to go out of business just to furnish diversity of demand to a central station, when they are producing light, heat and power cheaper than they could do by burning coal for the heating and buying the current.

Mr. Martin thinks that there is little hope for Mr. Moses' scheme, and predicts, basing his view on the extraordinary progress which has been made in America in the last three years in tying in main stations and systems at extra high voltages situated many hundreds of miles apart, that "in fifty years from now the isolated plant will be an extraordinary thing."

The isolated plant can have no part in this tying-in scheme, but since it is in our midst it must be used to the best advantage, and this use, to Mr. Martin's mind, would be to keep it quiet and buy current from the central station, *except on the peak,* when it should be run for the purpose of keeping down the customer's maximum demand. A man who has a plant installed and under steam ready to run, who has therefore incurred all the standing charges, which are a very considerable part of the total cost of current production, will not let it be idle the greater part of the time, unless the central station can sell him current for less than the bare price of extra fuel and labor, which is hardly believable.

The License Situation in Jersey

After much expenditure of time and money and patience, covering a period of thirty years, the engineers of New Jersey early this summer succeeded in having a license law passed. The act became a law in the closing hours of a special session of the legislature, and this was the reason advanced for the lack of an appropriation which alone could have and can now make the law worth more than the parchment on which it is written.

Unfortunately, the bill itself made no provision for an appropriation. It simply stated that the Commissioner of Labor should, within 60 days after the act became law, organize a bureau to carry on the work of examining and licensing engineers and looking after the enforcement of the law. The act became law on July 4. The bureau should have been established on Sept. 4. But the state has done nothing more toward making the license law a reality than if it never were written. The Commissioner of Labor has done all he can without funds.

Did the framers of this law, who were so profuse with their assurances to the engineers' committee, deliberately leave out of the bill provision for an appropriation—a vital requisite? Did the able legislators intend to so write the law that it would appease the engineers and at a later date, after the hand shaking and congratulations, prove worthless? Did the Solomons at Trenton think to make sport of this last committee as it has of so many previous ones? Thirty years' experience with the New Jersey legislature inclines one to think so.

At least, the law is a reality on paper awaiting only the

funds necessary to make it actually real in practice. The next session of the legislature is months away. There is plenty of time for everyone interested to write to the assemblyman in his district, pointing out the need for this appropriation. Let the engineers of New Jersey force the legislature to show its hand.

Flooded Cellars in New York City

New York City suffered from a cloudburst Thursday evening, Sept. 4. Many hotel and other cellars were flooded with water to a depth of seven feet and special pumping arrangements were necessary to get the water out. This is the second time this summer that serious flooding has occurred in the district between Twenty-third Street and streets along in the hundreds.

The cause is choking of the "traps" formed by looping the sewer lines under the subway.

Most hotels, apartment houses and office buildings have pumps for the heating system, though they do not have their own power plants.

Many of the buildings equipped with pumps for heating only use motor-driven pumps in which case the pumps may be quickly started. By simply putting in a tee and a valve in both the suction and discharge lines, the flood water may at least be pumped into the street as fast as it flows into the building. A couple of lengths of pipe so used would mean the prevention of much more damage, due to these choked sewers, because the conditions will surely be repeated before the volume of the sewer pipes is increased.

Boiler Performance Curves in Boiler Room

Recently a correspondent told how valuable a chart with curves showing the kilowatt-hour output and cost of coal per kilowatt has proved in his plant when posted in the boiler room. The curves in this plant are plotted weekly and the men took such an active interest in the chart that they reduced the coal consumption materially at practically no expense to the management. Such a plan is not new, but it is altogether too uncommon, considering its potentialities for good.

It does not require argument to convince one who recognizes the peculiar psychic traits of men that the efficacy of such methods of getting men to do their best is well worth while. Every honest man who loves the approbation of his fellows wants to excel in work, in sports, in everything that he does, when he knows he has a competitor. Any fireman can acquire the skill to get as much out of boilers and fuels as any other fireman can. Unlike many of the sports, there is a limit of excellence in firing boilers that is within the reach of any man who will honestly try. Consequently, one should not fear a labor disturbance by introducing a performance chart in the boiler room. It is the shirks only who would object.

It is better to have the curves plotted every day instead of every week as our contributor has done. The interest of the men is kept more keen. It is sometimes difficult to arrive at reasonably accurate figures regarding the cost of fuel per unit of output and the enthusiasm of the men is not one whit greater than when the coal consumption per day is plotted against the output per day.

The size sheet which is most convenient for plotting these curves is fifteen by ten inches. There are sixty quarter-inch spaces on the length of the sheet and forty on the width so that by making the ordinates represent days and abscissas output, a conveniently large chart is procured. On these sheets, which may be obtained in almost any store handling such goods, there is margin enough to print the necessary letters and figures; binders may also be purchased that these sheets will just fit. If the output variation from day to day is not too great and the required data are kept, a curve representing the cost of coal per thousand or any given quantity of kilowatts, might be plotted on the same sheet after it has been removed from the boiler room.

Encouraging Responsibility in Assistants

Ask the average engineer why he can't take a vacation, and he will reply: "Who'll keep the plant running while I am away?" Suggest that he must have an assistant, and you will probably get the answer, "Oh, yes, I've got a young fellow helping me, but he only takes care of the oiling and wiping, and does other odd jobs."

There is the reason why most engineers find things in chaotic condition upon return from an enforced absence and why they are fearsome of similar consequences when they would like to take a little time off for necessary recreation.

Every engineer should see to it that there is someone around the plant who can carry on his work at any time—one who not only can keep the wheels moving, but who can keep the plant running at its best efficiency while the engineer is absent. The logical man to be trained to this work is the man who has seen how the engineer does things—the man to whom he has explained why these things were done—his assistant.

Every chief should make it his business to explain to this understudy the whys and wherefores, discuss with him the solution of the various problems which arise, instill in him confidence by gradually assigning to him the performance of the minor duties, encourage him to carefully read and study the technical books and papers, and when the occasion arises it will be found that he is a real assistant, not one in name only, but in ability to accomplish things also.

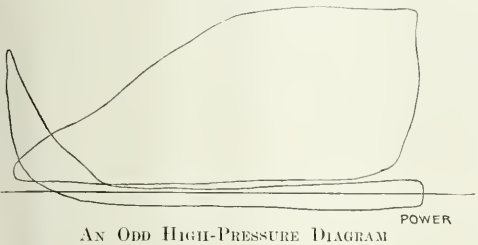
Not only will the educating of this young fellow be the source of a lot of genuine pleasure to his instructor, but the latter will find that the discussions and incidental references to standard works will refresh his own mind on many subjects, and that also it will enable him to go away for well earned recreation periods with the assurance that several weeks of hard work to get operating conditions back to normal will not be facing him when he returns.

The Federal Government has renewed its attack upon the Anthracite Coal Trust. We hope that the issue may determine not which particular set of individuals is to be allowed to bleed the industries of the country for what they can get, but the iniquity of the appropriation by any set of men of one of the necessities of our industrial life and the dealing of it out, not at a fair profit upon their actual investment, but at the price which those who must have it can be made to pay.

READERS WITH SOMETHING TO SAY

Peculiar Diagram

The accompanying diagrams are from the high-ressure cylinder of a Brown tandem-compound engine, unning about 100 r.p.m. with 125-lb. gage pressure of team. The valves were properly set and the engine vas running smoothly and steadily. A friend of mine ook the original diagrams. He simply raised the



An Odd High-Pressure Diagram

itch on the head-end steam valve while taking the card. There was a receiver pressure of 11 lb. gage at the time. Will some reader explain what caused the increased pressure in the latter end of the expansion line, also what aused the vacuum?

W. E. Chandler.

North Adams, Mass.

Some Temporary Jobs

While making my regular trip through the storage ooms of a refrigeration plant I noticed that a 1½-in. rine pipe, through which the brine was circulating, was eaking badly enough to damage the goods in the room. Permanent repairs could not be made in less than two ours and the necessary material was not at hand. The ipe was rusted badly, so I decided to use a bandage or stopping the leak. Strips were obtained from a ightly woven bag (malt or flour bag) and rolled up nd saturated with white-lead paint or cement. This vas applied freely to the inside face of the strips, while vrapping them around the pipe, pulling them tight. After one layer of the saturated bag was put on a mar-eted cement was applied. This was continued until the ipe had four layers over the leak.

A valve stem was attached to a 2-in. valve on a steam ine supplying a cooking kettle, the valve being near he ceiling and regulated from the floor above. When he operator went to open the valve, which was shut ight, the stem broke off where it went through the loor; not much time could be spared, for the contents f the kettle had to be cooked. A broomstick bored out t one end and hammered over the broken stem, and eing provided with a handwheel on the other end, served o operate the valve until there was time to renew the tem.

We have a pump on which a gland on the steam end had to be renewed. Instead of measuring the rod at its largest diameter when ordering the gland, the worn part of the rod was measured. The rod, therefore, stuck in the gland when the pump was started. The engineer not wanting to send the gland back to the shop, filed the hole bigger to fit the rod. After the pump was working packing would not hold in the stuffing-box because the hole in the gland was large and crooked. I took a hard-rubber valve disk, made it fit snugly around the rod and in the stuffing-box, after which it was cut in half and put in the stuffing-box next to the gland. The packing then held without trouble.

William L. Keil.

Philadelphia, Penn.

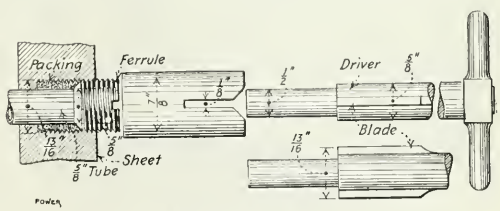
Removing Corroded Condenser Ferrules

The condensers on a small steamer required retubing, which meant that 6000 ferrules in each condenser head had to be removed.

When attempts were made to unscrew the old ferrules it was found that they were so corroded from the action of the water that they would crumble off flush with the face of the tube-sheet.

The customary operation in a case of this kind was to break off enough of the ferrule to get rid of the shoulder formed by the $\frac{9}{16}$-in. hole in the front end of the ferrule and with a drift the same diameter as the tube, drive the tube back inside of the sheet and remove the broken ferrule with a square drift, getting enough bite with the diagonal corners of the drift to back the ferrule out.

This operation had to be repeated on each end of each



Tool for Removing Condenser Ferrules

condenser, which made it necessary to retap the 12,000 holes. The ferrule driver was T-shaped and was forged from ⅝-in. round steel. On the working end it was turned down to a loose fit in the tube for a distance of 1½ in. After this came a fin-like projection on either side of the shank projecting out about $\frac{3}{16}$ in., thus forming the blade for the slot in the ferrule.

A piece of ¾-in. pipe about 2 in. long was secured and with a hacksaw two slots about ⅛ in. wide and 1 in. long were made opposite each other, then the four

corners formed by the slots and the end of the pipes were bent in toward the center and the pipe placed on the ferrule driver. The opposite end of the pipe made a neat fit over the ferrule. The turned end of the ferrule driver was put through the old ferrule into the end of the tube and the piece of pipe brought up touching the tube-sheet inclosing the ferrule, which was then screwed out, the pipe keeping it from spreading. With this device it was possible to unscrew ferrules having but one-half of the slot remaining by striking the end of the driver a few wraps with a hammer while in place.

We removed a great many ferrules which had no slots at all, that had been broken at the starting of the job. The cost of time and material in making this tool was so trivial as to be hardly worth mentioning. The first device was made in 10 min., and was an acknowledged success, by actual count removing 60 to 70 per cent. more ferrules than by the old method and in one operation.

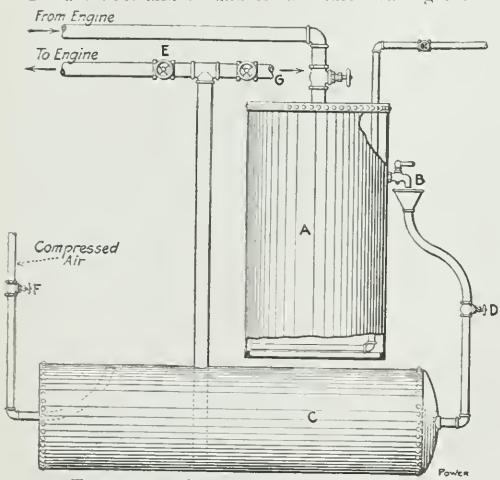
EDWARD M. DAVIS.

Philadelphia, Penn.

Cleaning Oil from Engine Crank Cases

Our engines are all of the high-speed, inclosed type and, of course, carry all but the cylinder-lubricating oil in the crank case. As usual, it is necessary to change this oil and clean it at intervals, 10 gal. per week being taken from each crank case and boiled with steam.

To save time and oil and to facilitate cleaning the oil



TANKS AND CONNECTIONS FOR CLEANING LUBRICATING OIL

the following system was installed. Two lines of 1-in. pipe were run from the crank cases of the engines to tanks in the basement. One line was used to draw off the dirty oil from the cases and the other to return the clean oil to them.

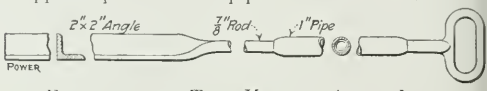
In the illustration, *A* is the boiling tank in which the dirty oil is heated. As stated above, 10 gal. of oil are run into this tank and boiled until the mixture of oil and water rises to within 2 in. of the top when the steam is shut off. As the tank *A* is lagged, it cools slowly and allows the dirt in the oil to settle. The good oil is then run from the pet-cock *B* into the tank *C*, which is an ordinary, domestic hot-water tank. Valve *D* is then closed and valves *E* and *F* opened and the oil blown to the engines as required. Valve *G* is connected to an oil-storage tank. The pipe *G* is a steam pipe and the tank *A* is partly filled with water through a pipe not shown. One man can run good oil from the tank *A* to *C*, take 10 gal. of dirty oil from any engine into the tank *A*, blow the good oil up into the engine and have the hose connections to the oil pipes cleared away within half an hour.

SAMUEL BURMFIRTH.

Montreal, Can.

Fire-Cleaning Tool

To help the firemen in cleaning fires, I made a bar 30 in. long and of 2-in. angle iron welded to a 7/8-in. steel handle of a length to suit our fireboxes, which are 8 ft. 8 in. square, with an effective grate area of 51 sq.ft. I slipped a piece of 1-in. pipe over the bar and welded



FIRE-CLEANING TOOL MADE OF ANGLE IRON

it at both ends so that it was stiff and strong just where it passed through the firedoor. With this bar one fireman can "wing" his fires over and have the whole fire cleaned and under way in from seven to ten minutes. Two men have cleaned one fire in three and a half minutes, with from eleven to thirteen hundred pounds of dry ash on the grates.

Montreal, Can. SAMUEL BURMFIRTH.

Cause of Knock in Pump

A more or less mysterious pound or knock will sometimes develop in pumps that have their sources of supply at a higher elevation than the suction valves. This knock is in the nature of a short jerk or kick at the beginning of each stroke. To one not familiar with such trouble, this would seem to indicate a loose piston or plunger. The cause of the knock is that the springs of the suction valves are too weak and the pressure of the water keeps the valves open until the pressure from the plunger closes them. The remedy is obvious.

Louisville, Ky. JOHN F. HURST.

Break in Cast-Iron Suction Line

Recently a serious break occurred in the 14-in. suction pipe of our condenser. As the plant had to be kept in continuous service, I repaired the break as follows:

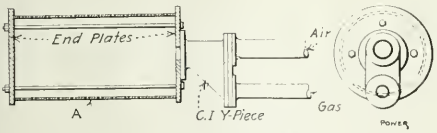
I used one quart of asphaltum thinned out with gasoline. To thicken it, I mixed in some ground asbestos until I had a thick paste. Then with a rag I cleaned the break nicely. After this was done I applied the paste until a ring about one inch thick was formed around the break. Next I bound this in with two rings of 3/4-in. tape and shortly the whole covering began to get hard. I then mixed up some ground asbestos and water and put a ring about 2 in. thick on top of this tape. For four days the condenser maintained 28 in. of vacuum with this joint in service.

Gary, Penn. W. D. LUCAS.

Burner for Heating Crank Disks

It is not unusual to experience much trouble in heating the crank disks of large engines, preparatory to shrinking the disk on the pin. A burner for this work which gives excellent results is shown herewith.

Referring to the sketch, *A*, is a perforated plate to



Burner for Heating Crank Disks

the ends of which two end plates are bolted, one end-plate is fitted with a cast-iron Y-piece for supplying air and gas. The diameter of the perforated plate should be about 2 to 3 in. less than that of the diameter of the crank bore. This burner may be made in various sizes to suit the different sizes of cranks.

John H. G. Morrison.

Glasgow, Scotland.

Abandoning a Boiler in Case of Fire

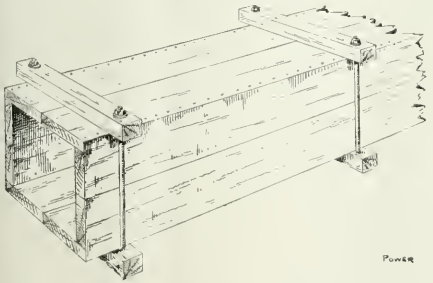
Here is a question upon which I would like to learn the opinion of other operating engineers. "What would be the best thing to do if a fire should break out in a plant using steam power, the boiler having a full head of steam on and a heavy fire in the furnace, and the fire in the building making such rapid headway that there would be no time to draw the fire?"

Fred W. Hener.

Baltimore, Md.

Temporary Wooden Flume Cheaper than Iron Pipe

A New England manufacturing company decided to build a new penstock and dam for the water end of their power plant, and as the water for the boiler feed, condensers and industrial purposes all came through the waterwheel flume it was necessary to run a pipe line



Showing Construction of Wooden Flume

from the plant to above the dam, some 800 ft. Not having permanent use for piping of the size required it was decided to build a flume of plank with the thought that the lumber would be of use after the new penstock was put in operation.

Two-inch planks, 18 ft. long, were used, costing (delivered) $30 per thousand feet. The clamps which held the flume together were 3x4-in. stock, and made of cheap hemlock lumber. The flume was 18 in. high and 16 in. wide. The wooden clamps were put on as shown, and spaced 4½ ft. apart; the rods for the clamps were of ⅝-in. common iron. The discharge end of the flume was connected to the main supply pipe in the basement of the engine room by cutting a square hole in the main pipe to receive the water from the flume.

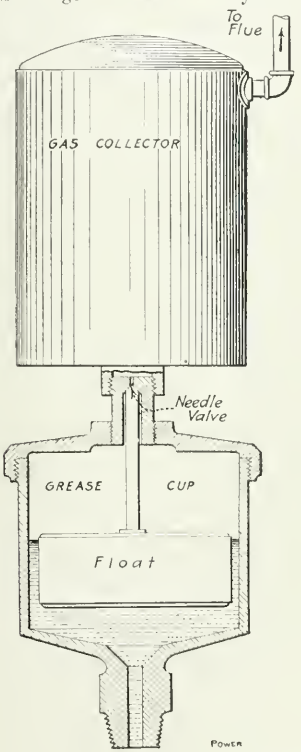
The first cost of the flume was less than the estimate of a contractor who bid for the job of putting in a cast-iron pipe 18 in. in diameter. After the flume was taken apart the planks were sold in the company's yard for $15 per thousand feet, or half the price paid for them.

L. Johnson.

Exeter, N. H.

Uniform Discharge Valve

If the water in a tank or flue-gas collector is permitted to drip through a constant opening the rate of discharge varies with the head in the tank and the gas sample will not be an average one. A valve may be made from



Valve to Give Uniform Flow from Gas Collector

an old grease cup, and connected to the tank to give a constant discharge rate with a varying head of water. The outflow is dependent upon the water level in the cup, and independent of the water in the tank.

Middletown, N. Y. R. A. Brownell.

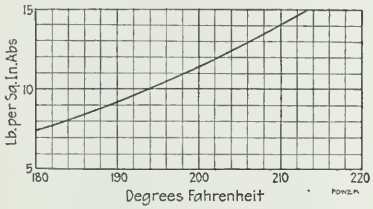
QUESTIONS BEFORE THE HOUSE

Measuring Water in Boiler Test

On page 830 of the June 10 number, James A. McHollan describes an arrangement for weighing feed water during a boiler test in a plant having an open heater. I wish to offer some comment upon this scheme, on the two points of feasibility and capacity.

His sketch shows the lower or suction tanks below the level of the pumps. As has been remarked by William Taylor, July 22, page 111, this arrangement will not work with water heated to nearly 212 deg. But need the water be run that hot? And how low must its temperature be held to insure proper suction?

An open heater of ample size is capable of raising water quite or very nearly to 212 deg., F., and must therefore be set high enough to supply water to the pump by gravity alone, without help from the atmos-



Vapor Tension of Water Plotted against Temperature

phere, because the hot water can give off vapor at atmospheric pressure. At the very least, the head from nominal water level in the heater to the pump cylinders ought to be 6 or 7 ft., and a little more is desirable if the heater may be expected to run very hot. This head is, roughly, equivalent to a pressure of about 3 lb. per sq.in.

Now the vapor tension of water, or the absolute pressure of its steam, varies with the temperature as shown by the accompanying curve, which is plotted directly from the steam table. At 200 deg., the steam pressure is about 3 lb. less than normal atmospheric, at 190 deg. it is nearly 5.5 lb. less.

Personally, I do not like to run water at more than about 190 deg. through such an open-weighing system. Hotter water gives off so much vapor as to be very annoying to the man operating the tanks and not any too good for the "works" of the scales; besides, it thus loses some weight, although perhaps not enough to be of much practical significance. With this limit imposed by outside considerations, there will be plenty of margin between atmospheric pressure and vapor tension to take care of a couple of feet of suction lift.

A question arises as to the control of this water temperature, and perhaps its temporary lowering during the test. In a condensing plant, with dependence upon returns and the exhaust from auxiliaries for heat, there is not likely to be trouble with too hot water. If the heater is of the shunt or cutout type, partial closing of the cutout valve may be effective—although this is only a tentative suggestion, not backed by experience. If all the exhaust from the main engine goes through the heater, the water must be taken as hot as it comes. Then a special cold-water pipe, fixed up so as to swing over the weighing barrels and discharging a small stream into the barrel being filled, seems a likely expedient for tempering the hot water.

After all it is a very good thing to set the heater sufficiently high at the start. The extra cost of an 8-ft. support over one 4 ft. high will be well made up when the time comes to make a boiler test.

As to capacity, the barrels shown by Mr. McHollan are presumably of the common oil-barrel size, holding 400 lb. of water. With high feed temperature, 1000 boiler horsepower will mean at least 32,000 lb. of water per hr., or 80 barrels. Then each of the two barrels will have to be filled, emptied and twice weighed in one minute and a half. Some hustling that! In fact, it could not be done with the sluggish flow due to the small heads involved.

With two barrels draining from an open heater through 2-in. valves, I should not care to undertake to handle over 500 boiler horsepower. For 1000 hp., I should put in 3-in. valves and would want tanks of at least 800-lb. capacity each, and a 1200-lb. suction tank. This would keep one man busy enough but would leave some margin for a peak load.

Robert C. H. Heck.

New Brunswick, N. J.

Orsat vs. CO_2 Recorder

In reference to the recent letter by A. Pohlman, entitled "Orsat or CO_2 Recorder Best," I wish to make the following comments:

While it is true that the CO_2 recorder does not show CO, and it would be foolish to collect an average sample without ascertaining the percentage of CO as well as CO_2, nevertheless, for a spasmodic sample an engineer after a number of tests can tell whether any serious amount of CO is contained in the sample by the percentage of CO_2, provided that the furnace is normal, and is worked under normal conditions. An abnormal state of affairs may produce anything, as a CO_2 recorder gives a constant reading and not an average sample. One can keep 14 per cent. or less CO_2 and be safe as far as CO is concerned.

Almost everything above 14 per cent. will show some CO, and what difference does it make how much is there, the fact that it is indicates not enough excess air, and therefore the CO_2 reading should be brought down until no serious amount of CO is contained in the sample, which under normal furnace conditions the writer finds to be 14 per cent. CO_2 or 50 per cent. excess air.

It is true that it is impossible to cheat the collector,

so long as the machine collects a uniform sample of gas. The ordinary bottle turned upside down, allowing water to drip out, thus taking in the gas, is easy to cheat, as three or four times as much water goes out in the morning as in the afternoon, due to the difference in head pressure. [See valve, page 405.—Editor.]

It is an easy thing to get gas into a bottle and get it out again for analysis, but it is another thing to get a correct average sample. The bottle scheme for collecting gas is unscientific and unsatisfactory. In a large Eastern plant they have a number of bottle collectors, and an actual test proved that they could not tell from the sample in the bottle within 2 per cent. CO_2 what the real average was. For example, if the bottle sample analyzed 10 per cent., the true average might be as low as 8 or as high as 12 per cent.

While Mr. Pohlman's statement regarding several other troubles with CO_2 recorders, such as weakening of the absorption solution, breakage, etc., may be true of some older types, the later types certainly do not cause trouble. The writer knows several of one make that have run for about a year without being touched, outside of changing charts each day and charging with caustic solution every other week. These machines have been checked up with the portable flue-gas analyzer and the solution has never failed to take out all the CO_2.

The Orsat was designed by a French chemist about 75 years ago. It is substantially the same now as it was then. There have been numerous modifications of the Orsat by chemists who never intended the instrument for engineering uses. There is no engineering supply house dealing in Orsats. The laboratory houses all sell them, and some engineers buy them because they do not know that there is an engineer's analyzer on the market—an instrument designed by an engineer and especially adapted for the use of engineers.

Walter C. Edge.

Collingswood, N. J.

Steam-Tight Valves?

In connection with the report on page 157 of the July 29 issue of tests on a 13x15-in. Skinner engine showing a nearly constant steam rate from ¼ to 1¼ load, the reason being found in a steam-tight valve, it may be of interest to call attention to the first report of the Committee on Steam-Engine Research of the Institution of Mechanical Engineers, Mar. 17, 1905. The report was based on an extensive series of tests to determine, among other points, the amount of leakage past slide valves and the effects of condensation and reëvaporation. The steam ports on the engine used for the experiments were blocked and it was run by power. The valve was of the Meyer expansion type. The cylinder heads and barrel were jacketed.

It was found that the leakage from the steam chest to the exhaust was nearly proportional to the square roots of the differences in pressure, that it was less with good lubrication, less with increased overlap of the valve, and that with well fitted valves, the amount of leakage may be over 20 per cent. of the steam entering the cylinder and is rarely less than 4 per cent. *Machinery* for May, 1905, page 483, gives a digest of the report.

Charles H. Chase.

Stoneham, Mass.

Preventing Air-Driven Pumps from Freezing

On page 138 of the July 22 issue, H. E. Leonard raises the question of how to prevent an air-driven pump from freezing without heating the air.

In a recent issue, F. M. Benjamin offers two suggestions. Without wishing to seem to criticize Mr. Benjamin, the remedies proposed are inadequate to meet the situation as it confronts Mr. Leonard.

The first suggestion made of allowing the pump to stop for five minutes and thaw out would never avail except under circumstances requiring only irregular service. The second suggestion of spraying water through the exhaust pipe by means of ⅛-in. pipe connecting with the discharge of the pump, will only prevent freezing in that portion of the exhaust in which the water is kept flowing. It will not help matters back at the cylinder where water is actually freezing, and gradually closing the exhaust passages. In cold weather spraying water into the exhaust pipe would, perhaps, soon cause the outlet to be frozen entirely.

In the usual installation the supply pipe drains toward the pump and a drip valve should be placed to take care of the condensed vapor before it reaches the throttle. The supply line should be blown through prior to starting the pump. Immediately the air passes the throttle a rapid expansion takes place with resulting cooling and ice will form on the slide valve and in the passages.

A mechanical mixture of oil and water in a semi-saponified condition is difficult to freeze and even if frozen the resulting substance is of a flaky structure and very readily disintegrated.

The following method is dependent upon the above statement, I have tried it out on pumps operating in zero weather and met with success.

Place an ordinary sight-feed lubricator immediately beyond the throttle and on the pump side of it. Make up a mixture consisting of one part kerosene, one part engine oil and one part soap suds and violently shake until an unctuous, white liquid is obtained. Use this in the lubricator, allowing a feed of about three drops per minute.

Snow flakes will be formed and blown out of the exhaust pipe, but no ice will adhere to the surfaces of the valve chest or cylinder.

E. Hurst.

Boonton, N. J.

Why Engines Rock

In the Aug. 5 issue, John F. Hurst, in answer to an inquiry by H. R. Low, states that the reason for excessive rocking of an engine in most cases is caused by too much compression. Mr. Hurst by no means stated a number of other important and probable causes for such trouble. Some of these causes are late admission, no compression, unbalanced engine, poor foundation.

I was once called to correct a rocking engine which was direct-connected to an electric generator. At every revolution of this machine, it seemed as though it would jump from the foundation. This unit had a new concrete foundation, and the erecting engineer said that the trouble was due to the construction of the foundation,

while the concrete contractor blamed the engine. I applied the indicator and found that the engine did not take steam until almost one-half stroke. The trouble was caused by the governor being put together wrongly, so that all parts of the stroke were extremely late. On reassembling the governor, however, a very good diagram was obtained, and the vibration had ceased.

FREDERICK L. RAY.

Louisville, Ky.

Steam-Expanded Piston Rings

The issue of Aug. 26 shows illustrations of Mr. Gulbranson's steam-set piston rings. There is nothing new in connection with these rings, except the number of parts in construction, viz., the double-packing ring and the carrying ring beneath.

I used steam-set rings more than 20 years ago. I do not consider them a good thing for several reasons, the most serious one being that a cylinder wears out of size at the point of greatest pressure, or the points from admission to cutoff.

I bored one cylinder that was $\frac{3}{16}$ in. larger at each end than in the center, and needless to say the piston was not drilled with small holes for steam under the rings in any of the refit jobs.

BURT M. SEYMOUR.

Delphos, Ohio.

Corliss versus Four-Valve Engine

I read with interest C. R. McGahey's article on the above subject in the issue of July 8.

Mr. McGahey makes the following statement: "The thermal loss is greater in the four-valve engine, as the temperature of the cylinder is changed about twice as often as with the Corliss engine." This is so fundamentally incorrect that I cannot refrain from commenting upon it. The high-speed engine should theoretically have a better steam economy than the low-speed machine. One of the greatest sources of loss in the cylinder is due to the initial condensation of the entering steam. The low temperature of the exhaust steam cools the cylinder wall to a temperature considerably lower than that of the entering steam. This cooling of the wall requires a definite amount of time, and time is a very important factor in the amount of condensation and not the number of changes. With sufficient time the temperature of the wall would be reduced to that of the exhaust steam. Before such a reduction in temperature can take place the wall is again exposed to the high temperature of the entering steam. The rapidity with which this occurs, or in other words, the less time between high-temperature baths, the higher will be the wall temperature and the less will be the initial condensation. It is obvious that if the rotative speed is high the time which the cylinder wall will have for cooling off will be less, therefore there will be less cylinder condensation. Consequently cylinder condensation is theoretically less in high-speed than in slow-speed engines.

This principle has so long been recognized that I was much surprised that Mr. McGahey could have been so confused as to make the statement that the loss is greater "as the temperature of the cylinder is changed about twice as often." The author may possibly have had in mind that the same steam was always passing through the cylinder when evolving the theory that the number of changes in a given time are the determining factor. It has long been recognized as a fundamental principle in thermodynamics that if two elements are brought in contact, one having a higher temperature than the other, the one will give out heat which will raise the temperature of the cooler element and the cooler will give out "cold" (so to speak; strictly expressed, will absorb heat), and this will continue until the two are finally of the same temperature. This transfer of heat and "cold" requires time.

There are, of course, other factors than cylinder condensation that determine the final results as to steam consumption between the slow-speed and the high-speed engines, such as clearance, port opening, etc., but the high-speed machine undoubtedly makes a gain over the slow-speed in cylinder condensation. There is also another factor in favor of the high-speed machine regarding the cylinder condensation, and that is that the amount of cylinder area in the slow speed is greater than in the high speed, therefore the condensation loss will be greater, due to the greater radiating surface. In comparing the size engines mentioned in the article, 15½x18-in. four-valve at 220 r.p.m. with the 18x36-in. Corliss valve at 90 r.p.m., which would give about the same horsepower, the cylinder area of the Corliss-valve engine is about twice as great as that of the four-valve engine.

I assume that the indicator diagrams shown in the article have no relation to the tests reported as the four-valve diagram shows about 40 per cent. cutoff, which presumably is not the point of highest efficiency for the particular engine, whereas the Corliss shows about 20 per cent. cutoff, which is very close to the point of highest efficiency. From my experience and knowledge the modern high-grade four-valve (Corliss-valve non-releasing gear) engines are giving results better than the slow-speed Corliss engines. I have knowledge of a number of very complete and correct tests which have been made on four-valve engines. For example, one was a 240-hp. four-valve engine operating with 110-lb. initial steam pressure exhausting to the atmosphere, 220 r.p.m., and the steam consumptions in pounds of dry steam per indicated horsepower for different percentages of rated load were as follows:

Percentage of load	25	50	75	100	125
Lb. per i.hp.	24.7	21.25	20.9	21.17	22.9

It is very doubtful if results as good as these have been obtained on the slow-speed Corliss engine of the same horsepower rating operating under the same conditions.

I also have knowledge of several plants where periodical economy tests have been made on four-valve engines covering a period of years, showing that the steam consumption has not increased to any extent, in fact in some cases the steam consumption decreased after a period of considerable operation, which would tend to prove that the valves were tight.

S. F. FERGUSON.

New York City.

[Previous discussion of this subject will be found in the issues of POWER, September 24, 1912, April 8, 1913 and April 15, 1913.—EDITOR.]

INQUIRIES OF GENERAL INTEREST

Producer-Gas-Engine Results—What is the best average result with a producer-gas engine in pounds of coal per brake horsepower-hour?

W. G. M.

About 1½ lb., but most plants use nearer two pounds.

Steam Line Draining—Should a steam line to an engine be arranged to drain toward the engine or back to the boiler?

W. G. M.

The general rule for a steam line is to drain in the direction of flow of the steam, but it should drain from the first or boiler stop valve in both directions.

Operating Turbine Without Dry-Air Pump—Can any type of turbine connected to a barometric high-level counter-current jet condenser be kept running without an air pump?

M. F. K.

In case of failure of a dry-air pump on an ordinary barometric condenser the vacuum would be reduced and in a counter-current jet condenser the action would be the same, the air being drawn down with the discharging water. The turbine could be kept running but not with the same load and steam pressure as the vacuum would be reduced.

Oil for Draft Gages—What is the best nonvolatile oil for use in draft gages?

W. G. M.

Thin machinery oil makes a good nonvolatile oil for a draft gage. For an ordinary V-form of draft gage, if the gage is partly filled with water and an equal depth of oil is placed on the surface of the water in each leg of the gage, evaporation of water is prevented and the difference of level can be read off as inches pressure of water column without allowance for the specific gravity of the oil, as would be required in reading a tube containing only oil.

Combined Boiler and Furnace Efficiency—How is the combined efficiency of a boiler and furnace found, when the heat value of the coal and the weight of water evaporated are known?

J. W. D.

To evaporate 1 lb. of water from and at 212 deg. F., 970.4 heat units are required. If N is the number of pounds of water evaporated from and at 212 deg. and C the number of British thermal units to be realized in perfect combustion of a pound of coal, then the combined efficiency of furnace and boiler would be

$$\frac{N \times 970.4}{C}$$

Lifting Hot Water—What is the highest temperature at which water can be lifted by the suction of a feed pump to a height of 5 ft.?

F. D. S.

The temperature of vaporization of water at the absolute pressure of the pump suction. Lifting 5 ft., the pressure of the water column being

$$5 \times 0.433 = 2.165 \text{ lb. per sq.in.}$$

the pressure in the upper surface of the column would be

$$14.7 - 2.165 = 12.535 \text{ lb. per sq.in.,}$$

and the highest theoretical temperature at which water could be lifted would be 204.1 deg. F. Actually water cannot be lifted 5 ft. at this temperature because of the liberation of air from the water, occasional vaporization of the water, and leakage of air into the pump or suction pipe causing the pressure on the top of the column of water to be in excess of the theoretical amount of such pressure.

Injector or Inspirator—What is the difference between an injector and an inspirator?

H. H. S.

In marine practice and in some localities the terms injector and inspirator are used interchangeably. Commercially the term inspirator is almost exclusively confined to the product of one company, which differs in some important respects from the instruments commonly classed under the head of injectors. It consists essentially of a lifting-jet and lifting nozzle or injector proper. When the inspirator is in full operation steam is admitted to the first nozzle to deliver the supply water to the force nozzle by which latter the water is forced into the boiler. Although the lifting and force nozzles are fixed their proportion to one another is such that the instrument requires no adjustment for changes in steam pressure or water supply, the waste valve being kept closed while the instrument is in operation except when starting the operation of the force nozzle. There are other types of double-barreled injectors, but only one goes under the commercial name of "inspirator."

Steam Consumption from Indicator Diagram—How can the steam consumed by an engine be determined from an indicator diagram?

F. E. B.

The simplest method is to use the formula:

$$M = \frac{13{,}750}{\text{Mean effective pressure}} [(C + E) \times We - (H + E) \times Wh]$$

which gives the weight in pounds per indicated horsepower per hour

C = Proportion of the stroke completed at a point on the expansion line which should be taken near the point of actual cutoff or near the point of release.

H = Proportion of compression.

E = Proportion of clearance.

We = Weight of 1 cu.ft. of steam at the pressure of the point considered.

Wh = Weight of 1 cu.ft. of steam at the compression pressure.

We and Wh are to be found from tables of the properties of steam.

Boiler-Opening Reinforcement—How should the relative dimensions of a reinforcement for a hole in the barrel of a boiler for a dome opening be figured?

W. N. A.

The opening being oval or elliptical in shape, not over 17 in. long and 13 in. wide, with the longer axis placed in a circumferential direction of the shell, a strengthening ring should be riveted around the hole (generally placed inside of the shell) and the cross-section of this ring should be at least as strong as the longitudinal seam of the boiler. The Massachusetts and Ohio regulations require such rings to be of wrought iron or cast steel with a net cross-sectional area, taken on a line parallel to the axis of the shell, not less than the cross-sectional area of the plate removed on the same line.

For instance, if a 17x13-in. dome opening is made on the top of a boiler with the length of the opening circumferentially of the shell, and the boiler shell is made of ½-in. material, then

$$\tfrac{1}{2} \times 13 = 6\tfrac{1}{2} \text{ sq.in.}$$

will be the greatest cross-sectional area of shell removed. One side of the reinforcing ring, therefore, has a net cross-sectional area of

$$6\tfrac{1}{2} \div 2 = 3\tfrac{1}{4} \text{ sq.in.}$$

If the ring be ¾ in. thick and riveted with two rows of $\frac{13}{16} = 0.8125$ in. diameter rivets, then as each rivet would remove 0.75-in. thickness of ring × 0.8125 in. diameter of rivet = 0.609 sq.in., and assuming that there are two rows of rivets which, although staggered, should both be assumed as in the same cross-section of the ring, then the gross cross-section of the ring should be

$$3.25 + (2 \times 0.609) = 4.468 \text{ sq.in.,}$$

and the ¾-in. thick ring would be

$$\frac{4.468}{0.75} = 5.95 \text{ in.,}$$

or practically 6 in. wide for the ring to restore the full strength of plate removed.

If the ring is to equal the strength of the longitudinal seam, then multiply the width (found to be 6 in. as above) by the efficiency of the longitudinal seam of the boiler.

ENGINEERS' STUDY COURSE

Evaporation—IV

Solution of Practice Problems

The factor of evaporation for the conditions specified in the problem given last week may be ascertained by means of the formula, also given last week:

$$F = \frac{(H - t) + 32}{970.4}$$

By referring to the steam table given in the issue of Sept. 2 it will be seen that the total heat of steam at 120-lb., abs., pressure is 1189.6 B.t.u. Then substituting in the formula, we have

$$F = \frac{(1189.6 - 160) + 32}{970.4} = \frac{1061.6}{970.4} = 1.094$$

A boiler horsepower is equivalent to the evaporation of 34.5 lb. of water per hour from and at 212 deg. As explained last week the equivalent evaporation for any set of conditions is found by multiplying the actual evaporation by the factor of evaporation. Thus, the equivalent evaporation for the conditions given in the problem is

$$8670 \times 1.094 = 9485 \text{ } lb. \text{ } per \text{ } hr.,$$

and, hence, the number of boiler horsepower being developed is

$$9485 \div 34.5 = 275.$$

Steam Calorimeters

It is important to know the quality or the percentage of dryness of steam when comparing boiler or engine tests. If this were not known and taken into consideration the results of some tests would be misleading.

Moisture in steam causes inefficiency and when present in large quantities it is troublesome in the steam engine as it makes cylinder lubrication difficult and may cause knocking. It also tends to cause water-hammer in the pipes.

The device used to discover the percentage of moisture in steam is called a steam calorimeter. It is not like the fuel calorimeter (mentioned in the issue of June 10) which is used for estimating the heat value of fuels and the two should not be confused.

There are three principal types of steam calorimeter. One is the barrel, in which the steam sample is injected into a barrel of cool water and the increase in temperature and weight noted, from which data the quality of the steam can be estimated as in the lesson of Sept. 9. This type is not popular, however, because very slight errors in reading temperatures and weights cause large errors in the final results.

Another type is the separating calorimeter. In this the particles of moisture are separated from the steam by mechanical means in a manner similar to that used in an ordinary steam separator in a pipe line.

The third type is the throttling calorimeter, a form of which is illustrated herewith. Where the percentage of moisture in the steam does not exceed 4 per cent. and where the steam pressure is 80 lb., gage, or over, the throttling calorimeter is very accurate and convenient, hence, its use is preferable. When the contained moisture is greater than 4 per cent., this form of calorimeter is useless and one of the separating type must be used.

As the quality of the steam in the great majority of plants seldom falls below 96 per cent., only the throttling type of calorimeter will be taken up here. If its principle and operation are fully understood, no difficulty whatever will be experienced in mastering the principle and operation of the other types.

When steam in expanding forces the piston ahead in the cylinder of an engine it loses heat, which is spent in doing the work of making the engine turn and running the dynamo, shafting system or whatever the load-giving apparatus happens to be. On the other hand, when steam is permitted to expand from one pressure to another without resistance, as it does when flowing from a hole in a pipe or from a valve into the open air, it tends to retain all the heat it had.

To illustrate, assume that a boiler is generating steam at a pressure of 140 lb., abs., and that this steam is dry saturated. By referring to the steam table in the study course of Sept. 2 it may be ascertained that steam of that pressure has a total heat of 1192.2 B.t.u. per lb. of steam. If this steam were allowed to flow through an opening directly into the atmosphere, we would find that the temperature of the steam after it emerged from the opening, and its pressure had dropped to that of the atmosphere, was 302.9 deg.—that is, if we were careful to avoid error due to radiation loss. The temperature of saturated steam at atmospheric pressure is 212 deg. Then, this steam must be superheated

$$302.9 - 212 = 90.9 \text{ } deg.$$

The total heat of dry saturated steam at atmospheric pressure is 1150.4 B.t.u. per lb. This superheated steam has all the heat of dry saturated steam and some more, as its higher temperature indicates. The specific heat of superheated steam varies for different pressures and temperature, but for the above case would be about 0.46. Hence, the excess heat must be

$$90.9 \times 0.46 = 41.8 \text{ } B.t.u. \text{ } per \text{ } lb.$$

And this value added to the total heat of dry saturated steam at atmospheric pressure gives

$$1150.4 + 41.8 = 1192.2 \text{ } B.t.u.,$$

which is exactly the same as the heat contained in 1 lb. of the steam we started with, namely, dry saturated at 140 lb., abs., pressure.

Now, if the 140-lb. steam contained some moisture, the total heat in the mixture of steam and water would be less to begin with, and the difference between that heat and the total heat of steam at 212 deg. would not all go to superheating the steam at atmospheric pressure, but some of it would be used up in vaporizing the entrained moisture and the final temperature or degree of superheat would, therefore, be considerably lower than above shown.

For instance, suppose the quality of the steam were 98 per cent., that is, it contained 2 per cent. of moisture. The total heat of a pound of such a mixture of steam and water would be the heat of the liquid plus the latent heat of 0.98 lb. of steam, or

$$324.6 + (867.6 \times 0.98) = 1174.8.$$

Subtracting from this, the 1150.4 B.t.u., total heat in 1 lb. of dry saturated steam at atmospheric pressure, we have

$$1174.8 - 1150.4 = 24.4 \ B.t.u.$$

excess heat instead of the 41.8 we previously had. Hence, the degree of superheat would be

$$24.4 \div 0.46 = 53 \ deg.,$$

showing a final temperature, consequently, of

$$212 + 53 = 265 \ deg.$$

Thus, by permitting steam to flow through an opening into the atmosphere, observing the temperature change, and using precaution against error due to radiation, we may calculate the quality or moisture content of such steam. A home-made form of the throttling calorimeter—the device used in doing this—is shown in the accompanying illustration. It can be made of pipe and fittings as shown. Between the flanges tightly fit a ⅛-in. steel plate with a small orifice drilled through its center. This orifice should not be greater than $\frac{3}{32}$ in. in diameter; $\frac{1}{16}$ in. would be better. The thermometer wells can be obtained from any instrument supply house. One concern quoted the writer a price of $1.60 apiece for the size specified in Fig. 1. This price includes the mercury filling for the well. The thermometers should have a range up to 400 deg., F., at the very lowest. The same concern quoted a price of $3.50 each for thermometers of this range. While the calorimeter can be operated with fair success with only the lower thermometer and well, it is preferable to use both an upper and a lower; the increased reliability of results more than offsets the difference in cost.

When assembled and in place, the calorimeter should be well insulated with magnesia or other covering to eliminate radiation as much as possible and, hence, prevent error.

According to the boiler-testing code of the American Society of Mechanical Engineers, formulated in 1899, the nozzle *A* of the calorimeter "should be placed in the vertical steam pipe rising from the boiler. * * * and should extend across the diameter of the steam pipe to within ½ in. of the opposite side * * * none of these holes (in the nozzle) should be nearer than ½ in. to the inner side of the steam pipe."

Before any readings are taken it is best to let steam blow through the calorimeter at full pressure for 5 or 10 min., so that the entire apparatus will be thoroughly warmed up and error avoided. The thermometers should be tested for accuracy before used and if an important variation is found allowance should be made in the readings. For very accurate work corrections are made for the error caused by the exposure of part of the thermometer stem to the room temperature. But, such connections are far too small to be of real importance in every-day power-plant test work. So, they will not be considered here.

When making a test for the quality of steam have the valve of the calorimeter wide open and read both thermometers. The temperature shown by the upper thermometer should correspond very closely with the temperature of steam at the pressure being carried on the boiler. This temperature is given in the steam table. If an appreciable difference is found this may be taken as an evidence that either the steam-pressure gage on the boiler or the thermometer is inaccurate and both should be tested to locate the trouble.

After the readings have been taken, the quality of the steam may be estimated by the following formula, which appears more formidable than it really is.

$$Q = \frac{(H - h) + 0.46\,(T - T_1)}{L}$$

where

Q = Quality of steam expressed as a decimal fraction;
H = Total heat of dry saturated steam at atmospheric pressure, B.t.u. per lb.;
h = Heat of the liquid corresponding with the pressure carried on the boiler, B.t.u. per lb.;
T = Temperature as shown by the lower thermometer degrees, F.;
T_1 = Temperature of saturated steam at atmospheric pressure, degrees, F.;
L = Latent heat of steam at the pressure carried on the boiler, B.t.u. per lb.

To illustrate the use of this formula, assume that the boiler being tested is at sea level and that the temperature shown by the upper thermometer is 366 deg. and by the lower one, 266 deg.

Referring to the steam table, we would find that the steam pressure corresponding with the temperature of 366 deg. is 165 lb., abs. If this figure checks up reasonably close with the pressure as shown by the gage on the boilers, we may proceed with our calculating. In making the comparison, don't forget to subtract the atmospheric pressure from the figure showing the absolute pressure, in the present case, 14.7 lb.

All the factors, except Q and T, are given in the steam table; T, given by the lower thermometer of the calorimeter, is 266; Q will be the answer. Substituting,

$$Q = \frac{(1150.4 - 338.2) + 0.46\,(266 - 212)}{856.8} = \frac{837.04}{856.8}$$

$$= 0.977$$

That is, the quality of the steam is 97.7 per cent.

Practice Problem

At a plant considerably above sea level, the atmospheric pressure is 13 lb. per sq.in. A boiler was being tested for the quality of the steam generated. The upper thermometer of the throttling calorimeter used showed a temperature 377.6 deg., while the lower thermometer showed 286 deg. The steam-pressure gage on the boiler indicated a pressure of 177 lb., gage. What was the quality of the steam?

Ventilation Problems are to be studied experimentally during the next four years, under the direction of the following commission: Prof. C.-E. A. Winslow, of the College of the City of New York; Prof. F. S. Lee, of the College of Physicians and Surgeons, Columbia University; Prof. E. L. Thorndike, Teachers College, Columbia University; Prof. E. B. Phelps Massachusetts Institute of Technology; Dr. James Alexander Miller, New York City, and D. D. Kimball, of Richard D. Kimball Co., 15 West 38th St., New York City. A sum of $50,000 has been appropriated for the study, from a gift made by Mrs. Elizabeth Milbank Anderson to the New York Association for Improving the Condition of the Poor.

Soda-Ash for Boiler Waters*

By Charles H. Bromley

SYNOPSIS—The article deals chiefly with the troubles most often experienced when using soda-ash in boiler waters. The effects of diluted solutions are pointed out and a normal solution is defined. The reason why steam mains and valves corrode while the boilers are unaffected by the soda-ash is also explained.

The corrosion of boilers is, without doubt, the most serious problem that confronts many engineers. Among the "home" remedies none are so common and at the same time more misused than soda-ash. Before stating something of what is known about soda-ash, the following serves well as an example of one of those puzzling cases of corrosion that sometimes occurs.

Influence of Sulphur in Boiler Plate

It is well known that sulphur is one of the most corrosive impurities in steel. The sulphur in boiler plate is distributed over the metal in minute spots which are claimed by many to form centers in which corrosion begins, and experience in a plant of the London Electric Supply Corporation seems to verify the report:

A standby boiler was suffering from severe corrosion and soda-ash failed as a remedy. Examination revealed many blisters on the shell below the water line and each blister contained a liquid which held in suspension a black powder, which on analysis proved to be ferrous sulphide, while the liquid was free sulphuric acid. The feed water used was alkaline and free from sulphur.

Peculiar Action of Soda-Ash

It is some time since Heyn and Bauer confirmed the fact that diluted solutions of sodium and potassium carbonate promote corrosion, instead of stopping it, but even now very few engineers who use soda-ash know this and consequently do not know whether or not they are using soda-ash to the best advantage. The action of soda-ash is peculiar when used in boilers. It does not seem credible that a diluted alkaline solution will increase in corrosivity up to a certain concentration and then decrease to zero or nearly so, as the solution is made stronger, yet this has been proven true several times within recent years.

Interesting Experience with Soda-Ash

The most recent and perhaps the most interesting experiments on the action of soda-ash in steam boilers, are those conducted by Lieutenant Commander Frank Lyon, U. S. A.[1]

Lieut. Lyon was in charge of the boilers of the "Oregon," which were of the tubular type and fed with hot water from open tanks; the water being kept highly alkaline. Corrosion aboard the vessel was practically unknown. He later spent three years as senior engineer officer aboard the "New Jersey," the boilers of which were of the B. & W. type. Soda-ash had proven so good aboard the "Oregon" that Lyon used it in the "New Jersey's" boilers, but owing to the drums of these boilers being smaller than those of the "Oregon," the amount of soda-ash used was less because of fear of serious foaming. Corrosion troubles of the worst kind began immediately; in a period of two weeks twelve changes of boilers for renewing pitted tubes were made.

Weak Soda-Ash Solutions Corrosive

After three years in experimental investigation of the problem of preventing corrosion, Lyon learned what others before him had learned, namely, that different concentrations of soda solutions had different corrosive effects on various metals. He learned that the soda solution used aboard the "New Jersey" was so weak as to be most corrosive. If the solution had been of the strength or concentration of that used aboard the "Oregon" no trouble would have resulted.

Lyon called the concentration whose strength is just below the one in which local corrosion first occurs, the lower *limit* concentration, the one in which the rate of corrosion is maximum, the *critical* concentration, and the one just above that at which the last sign of corrosion appears, the *upper limit* concentration.

Proper Strength of Solution to Use

Without going into the details of these experiments, we can get the most important information for our purpose from Lyon's statement that "Any boiler using any water can be kept from corroding for any length of time, if treated with soda, and if its concentration is maintained at or above 3 per cent. normal alkaline strength."

The normal solution of soda-ash is 53 grams of pure soda-ash dissolved in 1 liter of water; 3 per cent. normal would be 55 grams per liter or 208 grams per gal. Understand from this that the water in the boiler must contain at least 208 grams of soda-ash per gal. in order to be of a strength of alkalinity that prevents corrosion, but do not suppose that 208 grams or nearly ½ lb. must be fed in with each gallon of water during normal operation of the boiler.

Initial Charge of Soda-Ash

Suppose we are to put a 100-hp. tubular boiler in service with water charged to 3-per-cent. alkalinity. The boiler will have approximately 5000 lb. or about 600 gal. of water when full to the normal water level. If 208 grams of soda-ash is needed per gallon of water, then we will have to put

$$\frac{208 \times 600}{453.6} = 275.13$$

say 276 lb. of soda-ash into the original water that enters the boiler preparatory to starting up.

Unless the boiler primes or there are water leaks or the blowoff is used frequently, little soda-ash will be lost from the boiler and the solution will remain at the proper concentration. After charging the water it is best, perhaps, to operate the boiler under usual conditions, titrating samples of the water taken from the boiler every few days to ascertain how much the solution has weakened. In this way it will not be long before one can

*From a lecture before the Technical Society of the Brooklyn Union Gas Co.

[1] "Journal" of American Society of Naval Engineers for August, 1912.

feed the proper amount of soda-ash to keep the alkalinity at about 3 per cent. normal and titrating will not be necessary except at long intervals, say two weeks. Those who do not understand titrating could use the old but simple method of suspending a piece of clean boiler tube in a sample of the water and add more soda-ash to the boiler water if the piece of tube shows signs of corroding in a period of 12 hr.

Boilers Unaffected but Mains Corroded

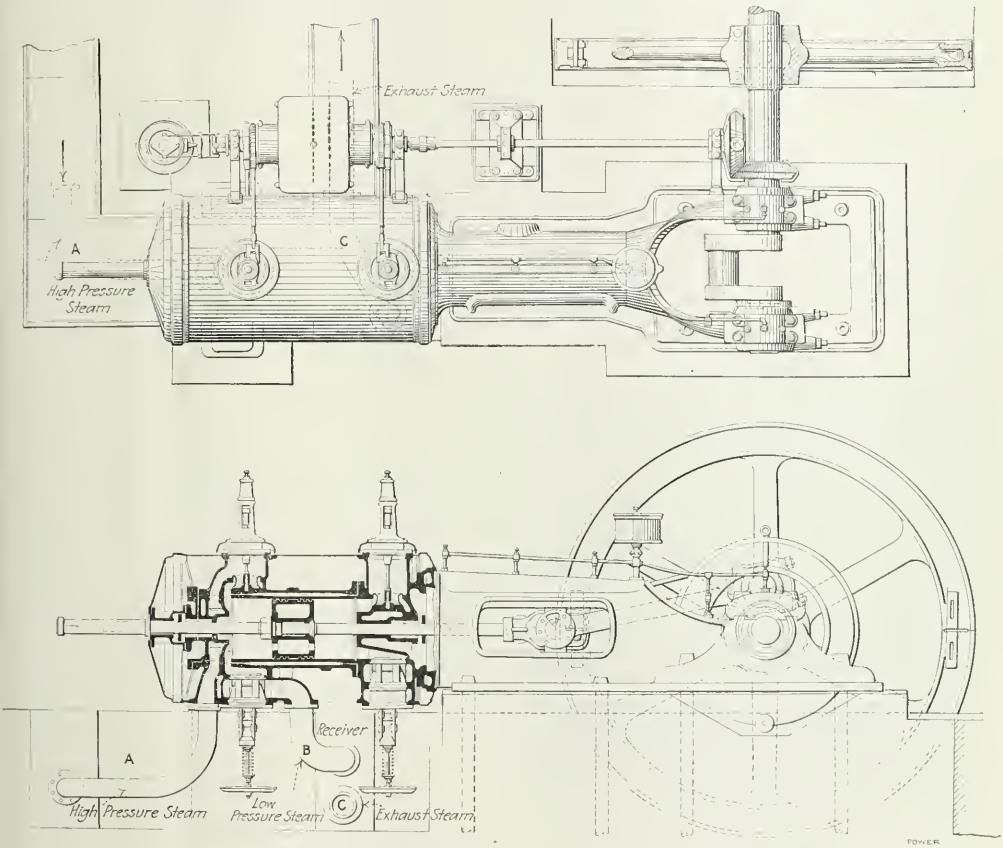
One of the most serious troubles accompanying the use of soda-ash is the corrosion, often rapid, of the steam main and its valves, though the boiler itself is free from corrosion, and perhaps the main does not corrode near the boiler but is seriously affected at points a short distance therefrom. This is due to priming or wet steam produced by other causes. A "slug" of water of high (safe) concentration goes over into the main, but before being drained away the concentration is reduced to the critical (unsafe) concentration by the water of condensation from the steam which is not alkaline. The best way of overcoming this trouble is to provide ample drains in the main near the boiler so as to get rid of the water before its alkalinity is reduced to the critical concentration.

When boilers prime due to the combined action of soda-ash and the impurities in the water it is well known that sodium phosphate or tannic acid will tend to prevent priming.

A Single-Cylinder Compound Engine

If a considerable part of the steam exhausted by the high-pressure cylinder of a compound engine is bled from the receiver for heating and manufacturing processes the low-pressure cylinder can be much smaller than if it had to work all of the steam which was admitted to the engine. We recall a compound at the Pacific Mills at Lawrence which was run backwards, that is the high-pressure steam was admitted to the larger, or low-pressure, cylinder, because so much was taken from the receiver that the smaller cylinder was large enough to expand and use what was left.

It is readily apparent, then, that under favorable conditions of bleeding the two cylinders of a compound engine might be of equal diameter, or rather that so much



A German Single-Cylinder Compound Engine, One Side of the Piston Taking High-Pressure and the Other Low-Pressure Steam

of the exhaust of the high-pressure cylinder may be used that the rest of the steam may be worked in a cylinder of the same diameter with the effect of a compound engine.

In the Missong, single-cylinder compound engine, built by Thyssen & Co. A. G. at Mülheim, this idea is utilized by using one end of a cylinder as the high- and the other end of the same cylinder as the low-pressure stage. Steam at boiler pressure comes to the engine through the pipe *A*, and is worked in the head end of the cylinder. The pipe *B* carries the high-pressure exhaust to the receiver, from which as much of the steam as is needed for heating, etc., is taken at *C*. The remainder passes to the crank end of the cylinder, where it is further expanded and exhausted to the condenser. The system is applicable only when at least one-half of the high-pressure exhaust can be used outside of the engine.

Beam Automatic Smoke Preventer

Another smoke-preventing device has been patented and is designed to automatically regulate the admission of air and steam to the furnace of a boiler. The device consists of a regulator for controlling the smoke-preventing apparatus, and a door deflector which causes the entering air to mingle with the steam from the jets. Fig. 1 shows the device, which is manufactured by the Rockford Smoke Preventing Co., Rockford, Ill., applied to a set of boilers. A detailed view of the apparatus is shown in Fig. 2.

This device consists of a rocker-shaft *A*, Fig. 2, mounted in brackets fastened to the furnace front. The

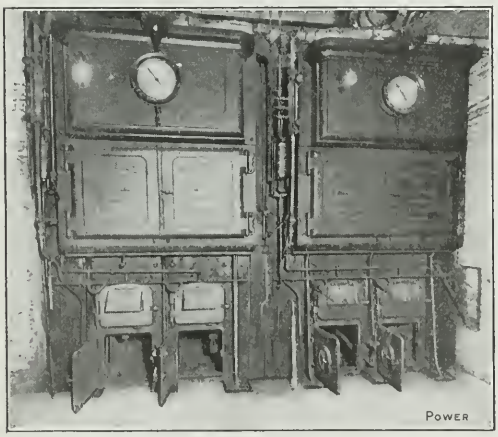


FIG. 1. SMOKE PREVENTER APPLIED TO RETURN-TUBULAR BOILERS

shaft carries the arms *B* which have a chain connection with the doors covering the air opening in the fire doors. This shaft is rocked through a link connection *C*, the arms being actuated through the contact of the fire doors when open, with the contact pieces on the lower shaft. Steam is supplied through the main pipe *D* and a control valve passes through the pipe *E*, from which it discharges through discharge jets over the fire in the furnace.

The regulator operates by the passage of oil through valves and the filling chamber which is filled nearly full with oil. When the fire door is open the motion is transmitted to the rocker-shaft *A*, and the piston in the cylinder is raised through the crosshead connection. This movement operates the damper and increases the draft, opens the steam-control valve, permitting steam to be discharged from the jets into the furnace, and also opens the air doors through which air is drawn and mixed with the steam from the jets.

As the piston rises the oil contained above it passes

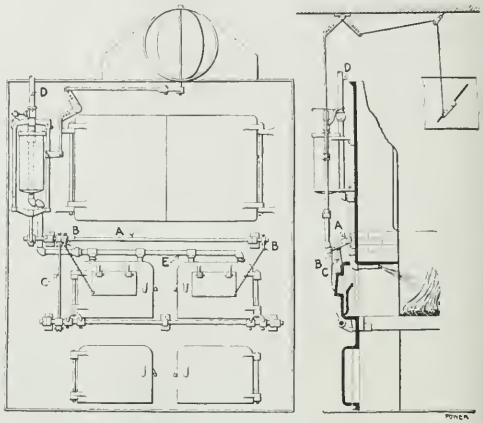


FIG. 2. DETAILS OF APPARATUS

through a valve which is opened by the weight of the oil. When the fire has been charged with fuel and the furnace door is closed, the weight of the operating part causes the piston to descend when the valve will be seated, and the oil will pass upward through a valve, thus causing the piston to slowly descend. During the time the piston is descending, steam and air are being discharged into the furnace, and as the piston reaches the end of its descent the oil in the bottom passes upward through a bypass, giving the piston a final quick movement to shut off the steam supply.

By a screw adjustment the degree of opening of a needle valve may be varied, and the length of the time required for the piston to descend is changed. When the piston is at the upper end of its travel and it is desired to have it descend quickly to an inoperative position, a bypass lever can be pulled, unseating a valve and permitting the oil to pass upward without restriction.

Illinois Coal Production in 1912—The production of coal in Illinois in 1912, reached the great total of 59,885,226 short tons, with a value at the mines of $70,294,338. These are record-breaking figures for the state, according to E. W. Parker, of the United States Geological Survey. The production in 1912 exceeded the previous maximum, 53,679,118 tons, made in 1911, by 11.6 per cent. The value increased 18.1 per cent. Illinois still fell below West Virginia in tonnage and continued third in rank among the coal-producing states. With regard to the value of the output, however, Illinois beat West Virginia by more in dollars than it was surpassed by that state in tonnage.

Texas Coal Production in 1912—The production of coal in Texas in 1912 passed the 2,000,000-ton mark, with a value at the mines of $3,655,744. These figures are record breakers for the state. The output of lignite in 1912 reached nearly 1,000,000 tons.

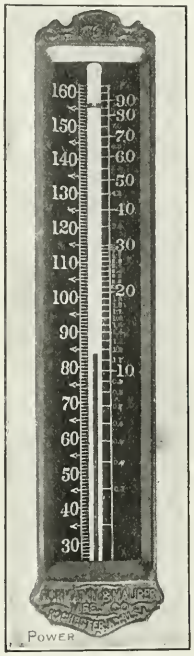
Absolute Pressure Thermometer

By W. H. Phillips

SYNOPSIS—By the use of a special thermometer the engineer is enabled to read the the temperature of steam in degrees F., and the absolute pressure in inches of the saturated steam in a turbine-exhaust head.

On steam turbines operating condensing, vacuum readings are usually taken by means of a mercury column, connected to the exhaust head of the turbine. These readings, subtracted from the barometer readings taken simultaneously, give, after making proper corrections for temperature and other variables, the absolute pressure, or back presure, against which the turbine is exhausting. Some engineers and turbine and condenser manufacturers specify or guarantee certain results when a specified number of inches of vacuum are obtained, referred to a 30-in. barometer. This is confusing to many and unnecessarily complicates an otherwise simple matter.

Two inches absolute pressure means the same whether obtained at sea level with a barometer at 30 in. or at an elevation of 10,000 ft. with a barometer registering 20 in. This great difference of elevation, of course, affects the amount of available energy in steam of the same initial gage pressure, but the back pressures have the same value and the same temperature. Saturated steam at 1 in. absolute pressure has a temperature of 79 deg. F. regardless of the barometer. No matter what the absolute pressure may be, we can find the temperature corresponding to this pressure in a steam table, and *vice versa*, knowing the temperature, the corresponding pressure can be obtained.



Absolute Pressure Thermometer

The writer has had a special thermometer made as shown herewith, graduated on the left side in degrees F., and on the right in inches and fractions of an inch absolute pressure. The two graduations are so arranged as to enable one to read the absolute pressure of saturated steam corresponding to the temperature recorded directly opposite. The cut shows the thermometer registering 84 deg. On the right-hand scale we read 1.16 in. absolute, which, if the instrument were connected to a turbine-exhaust head, would indicate that the turbine was exhausting against 1.16 in. back pressure or within that amount of a perfect vacuum.

This instrument was connected to the exhaust head of a 3500-kw. turbine located in a power station where readings are taken every hour of each of three watches. The operators were instructed to take the absolute pressure reading. All other readings were taken off the station instruments. Those of interest in this test consisted of a Standard U. S. Weather Bureau mercurial barometer and Standard H. & M. mercury column, both located on a gage-board within 6 ft. of the temperature pressure-gage. The mercury-column connection was tapped into the exhaust head of the turbine within 8 in. of the special thermometer being tested. All readings were taken under ordinary operating conditions and by the three regular operators on their different watches. The test lasted five days, the load on the turbine varying from 1200 to 3900 kw. and the vacuum from 1.3 to 2.4 in. absolute. Every reading taken was used in making the average result as given herewith:

Average absolute pressure as taken on mercury column and barometer, corrected for temperature	1.941 in. Hg.
Average absolute pressure taken on special thermometer	1.935 in. Hg.
Average difference in 100 readings	0.006 in. Hg.

The greatest difference found between these two methods was when the turbine was carrying an overload, and only under this condition was the temperature-absolute-gage reading higher than that taken by the mercury column and the barometer. The greatest difference, 0.110 in., being at 3900 kw., showing that the increased volume of steam was slightly superheated in passing through the last stages of the turbine.

The only conditions which may interfere with the accuracy of these readings are, the presence of air, conduction through the metal case of the instrument and superheat. Regarding air, Prof. Charles K. Carpenter, (on page 681, May 13, 1913) writes as follows: "Most of the air in the condenser seeps in through the pores of the condenser and the exhaust piping, and their joints, particularly the latter, the percentage of air present in the steam at the exhaust nozzle of a steam turbine is negligible." This statement agrees with the writer's experience that any leakage in the turbine nozzle head is usually at the shaft packing, which is easily discovered and corrected.

The inaccuracy due to conduction has been found to be negligible in well constructed thermometers properly installed. Superheat at the exhaust of a well designed turbine is impossible, except under heavy overload conditions.

The object of this article is not to advocate the use of the thermometer absolute gage for test purposes, but for station readings it is sufficiently accurate, easily read, and the chances of errors are minimized.

Power-Plant Records in a Small Station

SYNOPSIS—Records of the plant were kept by means of a daily log and a card system. The latter provided a means for checking the maintenance of the plant.

Several years ago, soon after taking charge of a pumping station in a Southern city of some 20,000 inhabitants, one of the company's officials asked the engineer if it

were practicable to keep a record of the engine-room expenses.

A daily log, covering such items as were then deemed necessary, thereafter was sent weekly to the office until the company sold out to the municipality. After this no records were sent in, as the city officials did not have the forms printed. Lately, the weekly report has been resumed.

During the interval, however, the records were regularly kept by the engineers and were extended from time to time to cover more details of plant performance. Although it gave much useful information, it did not furnish the information wanted, and the engineer, for his own personal use, adopted a card system which is quite valuable in checking the maintenance of the plant. The system carries not only all items that appear on the log, but many others that it would be impracticable to cover in this way.

All of the apparatus is individualized. In the boiler room, for instance, each boiler is numbered and all the accessory parts have the same number, such as furnace, setting, water column, blowoff valves, safety valve, gages, steam pipes, etc. These cards contain all data relating to the different parts, giving the time, material and nature of the repair. They are then grouped together in the file, all cards of the same heading, such as water column, going together in this specific information of any particular piece of apparatus.

The same order is carried out in the engine room, but in addition to the repair card, each engine and pump has two packing cards, one for steam, the other for water, and a valve card. They have a special value, as they not only furnish information as to the total cost of keeping up the supplies, but are a valuable means of comparing the relative merits of different manufacturers' goods when running under like conditions of service. These cards are filed in a vertical cabinet so arranged that any heading is easily visible. It is always at hand and it is not necessary to look back through a mass of records when information on any particular subject is wanted.

There is no record of the feed water as several makes of meters have been tried from time to time and discarded. Two tanks are erected on platform scales and once or twice a week the water is weighed for several hours, and, as the load is fairly constant, an approximate estimate is made of the average daily water evaporated.

A fireman efficiency record is kept, based on the percentage of CO_2 in his flue gases, both on the log and on a monthly form. In addition to the log and card system a loose-leaf ledger is kept, in which the unit cost of water pumped is recorded (the pumpage being based on plunger displacement) consisting of operating, maintenance and fixed charges. As it is not practicable to separate the maintenance and operating charges—the plant is too small to have a special card for upkeep work—the former is divided into five heads: labor, fuel, waste, miscellaneous supplies, and fixed charges. The total cost of each of these items for the 24 hours divided by the number of thousand gallons of water pumped gives the unit charge under that head. The whole combined give the total unit charge for the day.

Coal is the item subject to most variation in making up the daily charge, as it is necessary to estimate the cost at the furnace. This can be arrived at approximately in advance, the coal being weighed as it is hauled from the car and again at the boiler. It might seem that this means a good deal of bookkeeping, but as a matter of fact 30 minutes a day is ample time to check up and make all the necessary computations.

It does not make so much difference how much of a record the engineer tries to keep, it is the regularity with which it is done that counts. The daily log may be filled out in the evening, but the card system should be attended to immediately after making a repair, for if the charge is forgotten the system is valueless. The engineer may not have all the apparatus for accurately determining the output or performance of his plant, but he can know a great deal about it.

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Public Service Commission Acts in Landlord and Tenant Case

An important decision has been made in the case of Alonzo B. Knight against the United Electric Light & Power Co., of New York, in which the Public Service Commission has ordered certain contract riders to the rate schedules discontinued. These riders were as follows:

INCLUSION OF TENANTS' CONSUMPTION—WHOLESALE RATE

It is further understood and agreed that the customer will exclude all other electric service from the building and not install a private plant for light and power during the term of this contract, and to guarantee the use of 100,000 kw.-hr. annually in said building. Said guarantee shall include all current consumed by the tenants in the building as well as all current consumed by the undersigned. It is understood, however, that the accounts of the tenants shall have no further connection with the contract.

CONJUNCTIONAL SERVICE

It is further understood that in view of the fact that the buildings enumerated are supplied under the wholesale contract, are not more than 100 ft. apart, are under common ownership or leasehold, and may be served from a single center of distribution, the current required for them may be taken collectively in determining the rate to which the undersigned is entitled under this contract.

INCLUSION OF TENANTS' CONSUMPTION—GENERAL RATE

It is further understood and agreed that the owner or buildings enumerated in this contract are under common ownership or leasehold, are intercommunicating within the building, and are classed under one fire risk and operated as a single property, and that the owner agrees to purchase under this contract the current for all the apartments within the building or buildings, that the United Electric Light & Power Co. will furnish and set meters for said apartments and will render if required by the customer an itemized statement under this contract, giving the readings and numbers of the individual meters. Stores within the building or buildings are not classed as apartments. They may be included at the option of the owner or lessee.

It is further understood and agreed that the building or lessee will be responsible for the consumption of current within the building included herewith.

According to the first two riders the tenants under the general rate would pay 10c. per kw.-hr. for the first 250 kw.-hr. of monthly consumption, the rate gradually decreasing until it becomes 5c. per kw.-hr. for an excess of 1500 kw.-hr. of monthly consumption, the wholesale rate being available only upon the guarantee of 100,000 kw.-hr. of annual consumption. The landlord, on the other hand, in consideration of his promise to exclude all other service and not install a private plant, is granted a rate based not upon his own consumption but upon that of all his tenants taken collectively. In a memorandum

accompanying the order, Commissioner Maltbie cites the following example:

Assume that the landlord uses in one year 3000 kw.-hr. and in the month in question 200 kw.-hr.; that the total consumption of landlord and tenants is 150,000 kw.-hr. annually and that a certain tenant's bill for the month is for 200 kw.-hr.

The landlord will pay an average of 4⅗c. per kw.-hr. or $9.30, whereas the tenant will pay at the rate of 10c. per kw.-hr. or $20 for the same amount of electric energy.

The second rider simply permits the above to be applied collectively to all buildings under common ownership or leasehold which are not more than 100 ft. apart and which can be served from a single center of distribution.

Under the third rider the electric company installs and reads the meters on the tenants' premises, rendering to the landlord a statement accordingly. The landlord pays for this current at the wholesale rate and in turn charges the tenants at the retail rate, the difference amounting to a handsome profit for the landlord. An example under this rider cited by Commissioner Maltbie is as follows:

Assume an owner or lessee consumes in a certain month 5000 kw.-hr. and that no one of them uses more than 250 kw.-hr. The landlord will receive a statement from the company giving the reading of each meter and the total, which in the case assumed will be computed as follows:

First	250 kw.-hr. at 10c.	$25.00
Next	250 kw.-hr. at 9c.	22.50
Next	250 kw.-hr. at 8c.	20.00
Next	250 kw.-hr. at 7c.	17.50
Next	500 kw.-hr. at 6c.	30.00
Next	3500 kw.-hr. at 5c.	175.00
Total	5000 kw.-hr. at 5.8c.	$290.00

The landlord may now charge the tenants at the regular 10c. rate, which will be

4800 kw.-hr. at 10c. = $480

From this it appears that the landlord will get his current free and in addition will make a profit of $190 for a single month. But as he would have to pay at the 10c. rate if he had no rider, the latter has improved his condition to the extent of $210 per month as compared with the landlord who has no such rider in his contract. In a year this would amount to a fine profit.

Boiler Manufacturers' Convention

The twenty-fifth annual convention of the American Boiler Manufacturers' Association was held in the Hollenden Hotel, Cleveland, Ohio, on Sept. 1 to 4, inclusive. As usual, uniform boiler specification laws were the chief matter to receive attention.

The first session was opened at 2 o'clock on Monday afternoon with the customary address of welcome by the mayor, the Hon. Newton D. Baker, to which Col. E. D. Meier, president of the association responded. A. V. Cannon then gave an address on "Uniform Boiler Specifications" in which he took up the problems encountered and discussed them from their legal aspect.

At the Tuesday morning session the report of the Committee on Uniform Specifications and Construction of Boilers was read by Chairman Meier and approved by the vote of the association. A large delegation of the National Association of Tubular Boiler Manufacturers was present by invitation to listen to the reading of the report and discuss its provisions. The report is a continuation of the one presented last year at the New Orleans meeting and reported in our issue of April 2, 1912. During the year the committee send out a large number of letters requesting criticisms and comments on the report as made last year. From the 17 replies all of which were favorable it was assumed the report required no marked alteration. One change recommended was that all plates be stamped with the figure of the even 100 lb. nearest to the tensile strength figure shown by the test piece.

The membership of the National Association of Tubular Boiler Manufacturers, as its name implies, is composed solely of fire-tube boiler makers. It was organized a little over a year ago in Cincinnati and usually meets there about once a month. At the invitation of the American Boiler Manufacturers' Association it held its September meeting in Cleveland during the latter's convention so that the report of the committee on uniform specifications might receive joint consideration. The Tubular Boiler Manufacturers' Association has issued a set of standard specifications of its own which has been officially accepted and is used by 34 manufacturing concerns. This will be published in an early issue.

At the Tuesday afternoon session, L. J. Yeomans read a paper on "Factory Efficiency"; W. C. Connelly presented one on "Shop Costs," and T. E. Durban gave a third, on "Uniform Boiler Specifications."

UNIFORM BOILER SPECIFICATIONS

By way of introduction Mr. Durban stated that he thought that the manufacturers themselves had in a degree obstructed the securing of a uniform specification through petty jealousies and individual anxiety to secure slight selling advantages through changes in specifications. However, with ever multiplying state and city provisions for inspection, etc., and with the advantages and benefits to all of a uniform specification growing more apparent, the desired end seems encouragingly near.

Notwithstanding an existing federal law applying to locomotive boilers for interstate traffic, it was the opinion of President Taft and those senators and congressmen consulted and it is the present opinion of many able lawyers that a national law applying to stationary boilers would not be valid. The fact that a boiler is built in one state and shipped for use in another does not seem to bring it into the class of apparatus controllable by interstate commerce laws. Also, the common-sense argument that whereas the United States provides for marine boiler control it should also provide for stationary boilers, on the ground that life is no less sweet on land than on water, does not carry weight when it comes to legal validity.

Hope in the direction of a national law being faint, it remains for manufacturers and others interested to do all they can toward securing uniformity in the laws passed by the various states and cities. Existing laws have been found to be of great benefit as far as safety of life and property is concerned. But the lack of uniformity in them is a needless hardship on manufacturers and a real expense to the purchaser who, in the end, must pay for the cost of maintaining on hand the large assortment of stock which the manufacturer is forced to carry so that he may satisfy the diverse conditions imposed by the laws of various localities.

One glaring abuse, resulting from imperfectly framed laws, exists because in some cases the steel for some uses is specified as firebox steel while in other instances flange steel is satisfactory. Mr. Durban stated that from data in his possession apparently there was practically no difference between firebox and flange steel that came from the same mill as both showed the same chemical and physical properties. Therefore, it is his opinion that the difference between flange and firebox steel to pass Massachusetts, Ohio and Detroit inspection and the ordinary steel consists mainly of the extra charge which the mill must make in order to put the required number of stamps on the plate to meet the law. What Mr. Durban considers to be of far greater importance than stamps showing brand names such as firebox, flange, etc., are stamps showing mill-test numbers. These should be so placed that they would not become lost in the process of manufacture and would be accessible to the inspector.

In summing up, these specific recommendations were made: A factor of safety of 5. Specification of a uniform steel and that this specification cover flange steel. That the steel be marked with heat numbers instead of the brand name. A minimum tensile strength of 60,000 lb. per sq.in. That the steel be subject to the bending and quenching test. That the phosphorus content must not exceed 0.03 per cent.; sulphur, 0.04 per cent., and manganese, 0.5 per cent. That weldless crowfoot type braces be used of the same quality of steel as the plate, and that they be figured on a basis of 7500 lb. per sq.in. of section in the brace, and that on this basis no brace be used containing more than 1.28 sq.in. of sectional area. That through braces either above or below the tubes be weldless and be figured on 7500 lb. per sq.in. of area; that all seams be butt strapped with inside and outside covering strips. That all manholes be 11x15 in. That no plates be used in a tubular boiler thicker than ⅝ in. That all holes for rivets be punched ¼ in. small and reamed to size. That all flue holes be punched ½ in. small and reamed to size. That no cast iron be used in connection with the boiler either for reinforcement or any other purpose.

That all plates be beveled on a planer instead of sheared on a bevel shear. That water column connections all be 1¼ in.

Demonstration on a $\frac{5}{16}$-in. plate showed that it is impossible to do a good job on a splitting shear, and that the same objection that exists to a punched hole, holds good in the use of a splitting shear on thick plates. That is, that the metal is distorted by use of a splitting shear.

At the annual election on Thursday the following officers were elected: E. D. Meier, New York City, president; J. D. Farasey, Cleveland, Ohio, secretary; Joseph F. Wangler, St. Louis, Mo., treasurer; Thomas M. Rees, Pittsburgh, Penn., first vice-president; J. Don Smith, Charleston, S. C., second vice-president; H. D. MacKinnon, Bay City, Mich., third vice-president; L. E. Connelly, Cleveland, Ohio, fourth vice-president, and Robert Jay, Oswego, N. Y., fifth vice-president. The first six officers mentioned were reëlected, according to customary proceedure. New York City was chosen as the place for the next annual meeting which will be held in September, 1914.

Prominent among the entertainment features was an excursion by boat to Cedar Point which occupied the entire day on Wednesday and the annual banquet Thursday evening. The latter event was an especially festive one as it commemorated the twenty-fifth anniversary of the organization. Other entertainment features were an informal reception on Monday evening, an automobile ride for the ladies on Tuesday, a theater party on Tuesday evening and a shopping tour for the ladies on Thursday.

Boiler Carries 318 Per Cent. of Rating

In Bulletin 51, the Edge Moor Iron Co. gives results of three interesting tests on one of its 736-hp., water-tube boilers equipped with a Foster superheater and a Taylor stoker. The tests were made at the Westport generating station of the Consolidated Gas, Electric Light & Power Co., of Baltimore. The boiler contained a total of 7361 sq.ft. of water-heating surface and 429 sq.ft. of superheating surface.

In the first test of two hours' duration, 2340 boiler horsepower was developed. This is 318 per cent. of the rated capacity. The other two tests were run for eight hours and the horsepower developed was 210 and 248 per cent. of rating, respectively. In the order given the evaporation per square foot of water-heating surface was 10.97, 7.26 and 8.57 lb. The steam pressures were 172.1, 169.7 and 167.4 lb. In the same order the steam was superheated 103.5, 130.4 and 106.6 deg. The latter part of the bulletin is devoted to the time required to obtain a high rate of evaporation from a banked fire, and to the value of rear passes in a boiler.

A Cold-Storage Banquet

Foreign delegates to the Third International Refrigeration Congress which takes place in Chicago from Sept. 17 to Oct. 1 will be the guests of honor at a unique banquet at which only foods and beverages that have passed through refrigeration will be served. Most of the foodstuffs have been collected by the United States Department of Agriculture. Each delegate at the feast will be presented with a souvenir menu giving an officially certified history of each article of food served.

The frozen eatables now at Washington will be sent to Chicago prior to the opening of the refrigeration show to be held at the International Amphitheater and will be in the huge $10,000 ice box which will occupy the most conspicuous space at the exposition and will be used exclusively for the government exhibits.

Organizations which have arranged to hold annual or special meetings during the congress include the American Meat Packers' Association, American Association of Refrigeration, American Society of Refrigerating Engineers, National Ice Association, Eastern Ice Association, Western Ice Manufacturers' Association, Southern Ice Association, Southwest Ice Manufacturers' Association, Illinois Ice Dealers' Association, Indiana Ice Dealers' Association and the Louisiana Ice Manufacturers' Association. Many other associations will be represented by delegates.

Fastest Ship in the World—According to a special cable dispatch to the New York "Sun," the new Russian destroyer "Novik" is the fastest ship in the world, having developed 37.3 knots in her trials at Swanemuende. She was built at that place from designs by the Vulcan Company and was fitted with turbines and boilers made by that company at Hamburg and Stettin.

NEW PUBLICATIONS

THE GAS ENGINE HANDBOOK, Seventh Edition. By E. W. Roberts. Published by the Gas Engine Publishing Co., Cincinnati, Ohio; 323 pages; 4¼x7 in.; illustrated. Flexible leather. Price, $2.

In order to bring the book thoroughly uptodate much of the text of the previous editions has been rewritten and the formulas on design have been revised, wherever necessary, to correspond with present practice.

The text has been grouped under three general headings, namely: Descriptive Matter, Design, and Operation, Testing and Selection. Under the first heading are taken up the gas-engine cycles, fuels, valves, carbureters, vaporizers and mixers, igniters, governors, automobile, marine and aëronautical motors and lubrication. Under design, are considered the proportioning of the various parts, in which connection the various formulas are given. The third division includes suggestions for selecting an engine to meet different conditions, starting and stopping engines, troubles and how to remedy them, and rules for making and working up gas-engine tests.

The author has made a strong plea for the two-stroke-cycle engine, pointing out the false ideas about this type and the cause of its unpopularity in certain lines.

The whole treatment of the subject is thoroughly practical and the style is clear and concise. We have no hesitancy in recommending it to the engineer or designer desiring a ready reference on gas-engine matters.

PERSONALS

Freeman Wines, formerly of Newark, N. J., has taken the position of chief engineer of the New Metropolitan Hotel, Asbury Park, N. J.

John A. Stevens, Lowell, Mass., has just completed a term of six years as a member of the Massachusetts Board of Boiler Rules and has been succeeded by Frederick A. Wallace.

Stephen A. Staege and Raleigh H. Bennett, engineers, and Charles E. Dewey, architect, Watertown, N. Y., formed a partnership, Aug. 31, 1913, under the firm name Staege, Bennett & Dewey, engineers and architects.

William H. Sargeant, for the past 13 years chief operating engineer at the plant of the Prudential Insurance Co., Newark, N. J., has been appointed chief engineer. He will now handle the executive as well as the operating end of the plant.

Walter Pryor, for a number of years chief engineer of the Henry R. Worthington plant at Harrison, N. J., now holds the position of superintendent of plants for the Eclipse Tanning Co., with headquarters in Newark, N. J. Mr. Pryor has nine plants under his charge.

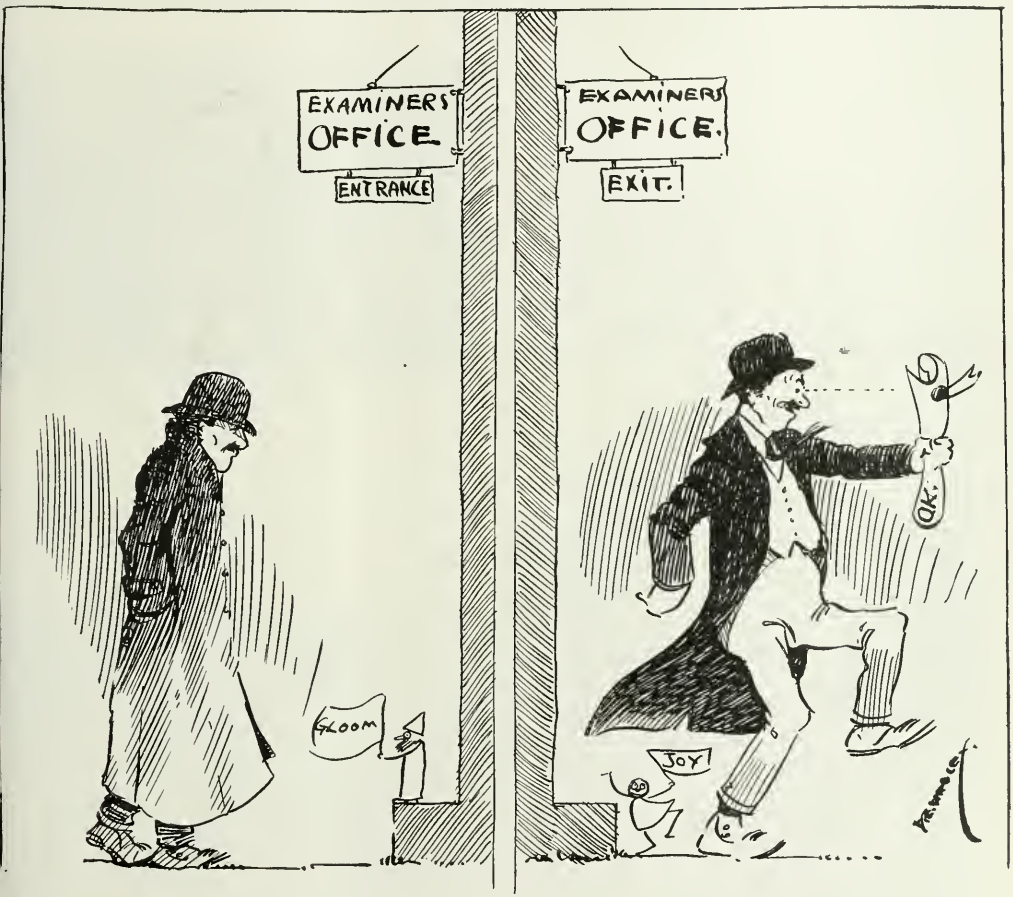
Otis Funderburk, formerly Michigan manager for the Findeisen & Kropf Manufacturing Co., maker of the Rayfield carburetor, has been appointed sales manager of the carburetor division of the Detroit Lubricator Company, which is making and marketing the Stewart carburetor.

Frank S. Washburn, of Nashville, Tenn., president of the American Cyanamid Co., Niagara Falls, N. Y., has been elected to fill the unexpired term of James Mitchell, formerly president of the Alabama Power Co., Birmingham, Ala. J. W. Worthington, of Sheffield, Ala., has been chosen one of the vice-presidents. Mr. Washburn is also president of the Goodman Manufacturing Co., of Chicago; is the consulting engineer of the Crescent Coal & Coke Co., Nashville, Tenn.; is a director in the American National Bank of Nashville, and is connected with other industrial and banking institutions.

Kansas Coal Production in 1912—The production of coal in Kansas in 1912 increased from 6,178,728 short tons, valued at $9,472,572, in 1911, to 6,986,182 tons, valued at $11,324,130, according to figures compiled by E. W. Parker, of the United States Geological Survey, in coöperation with the Geological Survey of Kansas. The gain amounted to 13 per cent. in quantity, and 19.5 per cent. in value. The average price per ton advanced from $1.50 to $1.62. The increased production in Kansas, as in the other Southwestern States in 1912, may be attributed to the diminished supply of fuel oil and natural gas from the Mid-Continent field. These fuels, especially fuel oil (on account largely of the increased demand for gasoline), have been virtually removed from the steam trade and steam users have returned to coal.

POWER

Vol. 38 SEPTEMBER 23, 1913 No. 13



BEFORE AND AFTER TAKING

(Drawn by Delevan E. Whaley, Reading, Mich. Acknowledgment is made to T. E. Powers for the use of the manikins.)

Features of the Lemp Brewing Company's Plant

SYNOPSIS—Eight Heine-type boilers fitted with instruments for securing high economy; ancient and modern types of boiler-feed pumps and a mixed-pressure turbo-generator are the chief distinguishing features of this modern, well kept plant.

As a class, brewery power plants rank high. The machinery is almost always of good construction and well kept and a cleanly well painted appearance is characteristic. In many plants, especially in those of medium and large size, much attention is paid to efficiency, both as regards type of apparatus and methods of operation. A plant which is particularly noteworthy in these respects is that of the Wm. Lemp Brewing Co., St. Louis, Mo., which furnishes light, power, heat and refrigeration for one of the largest breweries in the world.

A general exterior view of the boiler house only is given in Fig. 1; the engine house is to the right and the piping connections between the two are all carried on the covered bridge seen extending over the railroad track.

The present boiler equipment consists of eight O'Brien-Heine type water-tube units rated at 500 hp. on a basis

FIG. 1. GENERAL VIEW OF BOILER HOUSE

of 10 sq.ft. per hp. There is room for two more boilers of the same size. The boiler-room floor is about 15 ft. above grade level, the ash-handling floor being at grade. The working steam pressure is 125 lb., gage, per sq.in.

Coal is delivered in hopper-bottom cars which are run into the building on a trackway extending under one end. This trackway is provided with scales so that the car and shipment can be weighed just before the coal is unloaded and the weight of the empty car can be ascertained immediately after the delivery. The coal is dumped from the car directly into a crusher which discharges it to a bucket conveyor running beneath. This conveyor extends up the wall at one side, across over the bunkers and down the wall at the other side in the usual manner. The buckets are 18x24-in. in size, and the conveyor has a capacity of 80 tons per hour. The conveyor is driven by a 10-hp. motor.

ASH-HANDLING EQUIPMENT

The ash-handling arrangement is somewhat unusual. The boilers are located in two rows of four facing each other across a wide firing aisle. The ashpit hoppers are provided with special fireproof gates so arranged that the ashes can be dumped in the shortest possible time to avoid prolonged cooling of the boilers during cleaning. A narrow-gage track extends under the ash-hopper gates under each row of boilers and at each end turns and

FIG. 2. VIEW IN ASH ROOM, SHOWING HOPPERS AND CARS

runs across the room to a chute opening. Small steel hopper-bottom cars, as shown in Fig. 2, placed on this track, receive the ashes from these boilers.

The cars are moved by a small electric locomotive, designed by Wm. Koedding, master mechanic for the Lemp Co. Power for this locomotive is supplied through a double-trolley pole in contact with overhead supply and return wires, suspended from a wooden strip fitted with guard strips at each side. The locomotive motor is a 2-hp. high-speed machine, speed reduction being accomplished by a worm gear which is connected with the locomotive wheels by chains and sprockets. The motor-starting mechanism is operated by a lever at either end of the locomotive. To make the locomotive run in either direction a lever is pushed in the desired direction and held in that position. The levers are counterweighted so that when the hand is removed they immediately assume a vertical position and automatically cut out the motor. Due to this fool-proof construction a special operator is not required.

The gates of the ash hoppers are of the flat, sliding type and are opened and closed by a rack and pinion. They are lined with firebrick to prevent frequently burning out. The present set of gates has been in service for about 2½ years.

The conveyor carries the ashes to the top of the boiler house and dumps them into a large storage and weighing

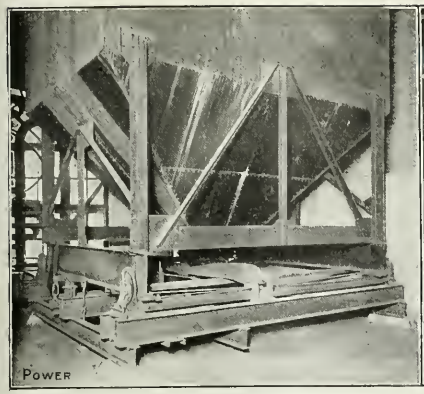


Fig. 3. Ash-Storage Weigh Hopper

Fig. 4. View in the Boiler Room

hopper, Fig. 3, which occupies a corner of the boiler room over the railroad trackway before mentioned.

The hopper is constructed of structural steel and sheet iron and lined with concrete to prevent corrosion. Its capacity is about 40 tons and it is fitted with a 40-ton beam scale. The ashes are weighed at the end of every 8-hr. shift and when an approximate carload has accumulated the total weight is taken as a check and the ashes are discharged by gravity to a car below and removed.

Siftings from the boiler stokers, which are of the chain-grate type, manufactured by the Laclede-Christie Co., are caught in bifurcated hoppers, one of which is shown in the foreground in Fig. 2. Four tracks, one under each pair of opposite boilers, extend across the ash room and each carries a car, similar to the ash cars, to receive the siftings. When a carful is obtained the car is pushed across the room by hand and the siftings are emptied into chutes which feed onto the conveyor and are carried to the bunkers above.

The stoker-driving shaft is hung on the ceiling of the ash room and the eccentric rod for each unit extends through a slot in the boiler-room floor. The stokers

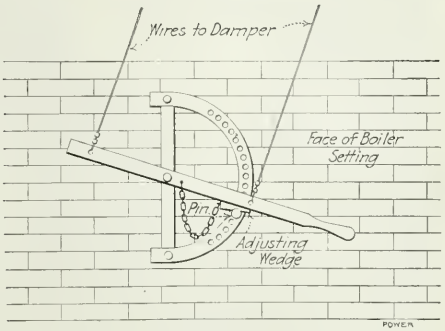


Fig. 5. Damper-Control Lever

are driven by a 10-hp. variable-speed motor. The speed may be changed by hand as required. A small high-speed vertical steam engine is provided for emergency use. The area of grate surface for each boiler is 100 sq.ft.

The chimney is of the radial-brick design and 250 ft. high above grates by 11-ft. inside diameter.

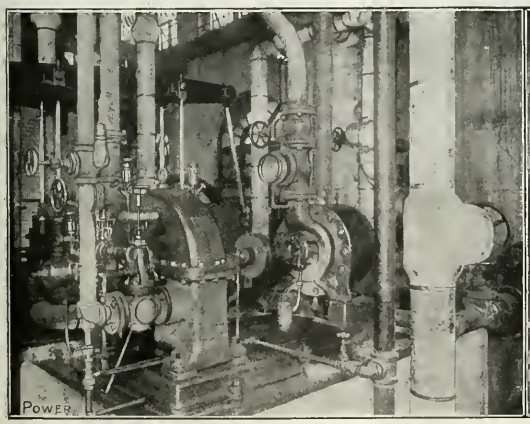


Fig. 6. Main Boiler-Feed Pump and Old Auxiliary

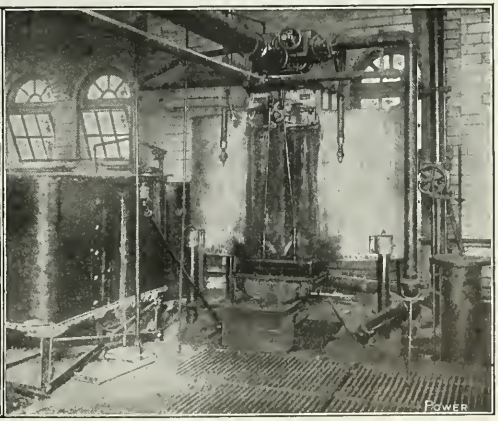


Fig. 7. Water Weigher and Boiler-Compound Tank

Boiler-Room Instruments

As especial attention is given to the matter of boiler-room economy, the boilers have an unusually complete equipment of gages and instruments. A bank of six Precision Instrument Co.'s automatic CO_2 recorders are located as shown in Fig. 4, six being all that are required, as more than six boilers are never operated at any time. These instruments are piped so that any one may be connected to any boiler.

The draft is controlled by an individual butterfly damper for each boiler and adjusted by a lever and wedge, as shown in Fig. 5, located at a convenient point on the side of the setting, as may be seen in Fig. 4. Near the damper-control handle on each boiler setting is a differential-type draft gage which indicates the draft on the boiler side of the damper. In addition there is a recording draft-gage connected with the main uptake of each row of four boilers. A record of the steam pressure is kept by a Bristol recording-pressure gage connected with the main steam header. A recording high-range thermometer registers the flue-gas temperature at the point where the breeching enters the chimney. The flue gases are periodically analyzed by hand as a check on the automatic machines. The feed water is measured by a Worthington meter and a Hammond water weigher, one serving as a check upon the other. The boilers are equipped with Bayer soot blowers and the heat-absorbing surfaces are kept thereby in a high state of efficiency.

Arrangement is made whereby any boiler may be tested without undue inconvenience, and, consequently, frequent tests are made.

The feed water is tested regularly for scale-forming ingredients and treatment is prescribed to suit.

Boiler-Feed Equipment

The three boiler-feed pumps are an interesting study in the art of steam-pump development. First, there is an ancient walking-beam steamboat type which has seen over 25 years of service. The beam, some of the water cylinders and connecting rods, and part of the crank

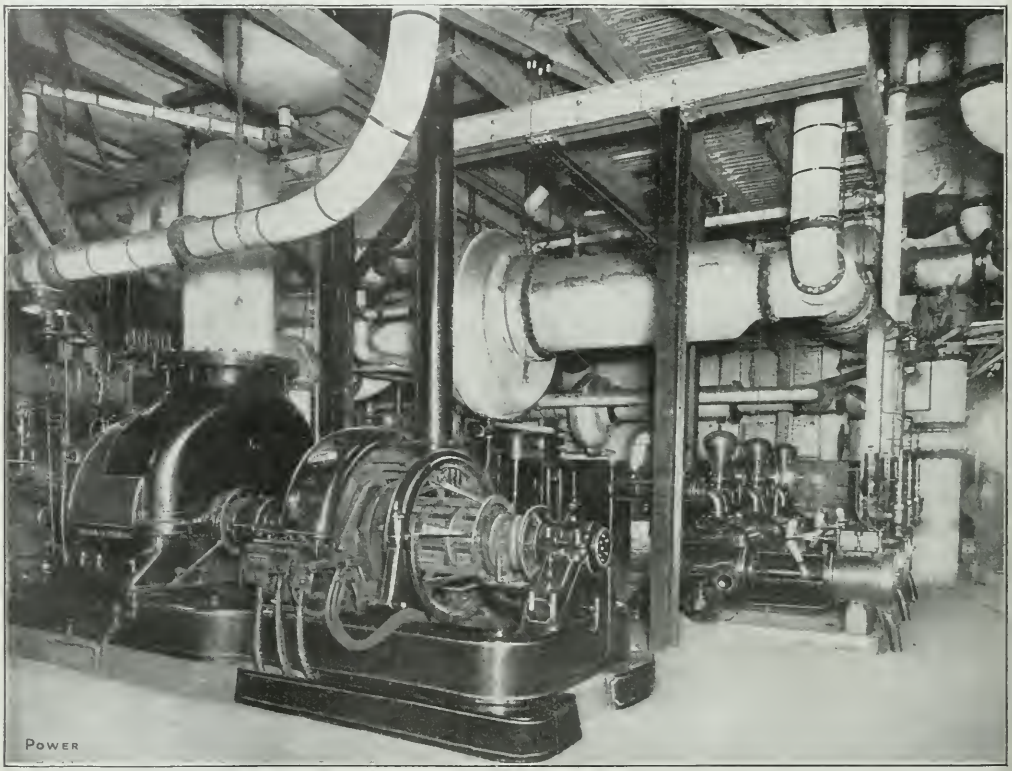


Fig. 8. Mixed-Pressure Turbo-Generator

disk, may be seen in Fig. 6. There are four 8x16-in. plunger-type water cylinders situated next to the center column supporting the walking-beam. Beyond these cylinders at the left is the one steam cylinder, which is 10x32 in. in size and double acting. Beyond the water cylinders at the right are the crank and flywheel.

This pump, although capable of good economy, as boiler-feed pump economies go, is now a sort of pensioner, and only used in cases of extreme emergency. Alongside of it and occupying the foreground of Fig. 6 is a turbine-driven centrifugal pump, typifying the latest practice in boiler-feed apparatus. This pump, with a capacity of 350 gal. per min., is the main boiler feeder. The third pump, an Epping-Carpenter 12x8x12-in. hori-

zontal duplex, located to the right of the turbine-driven unit, is employed only for emergency service.

The feed water is pumped from a closed heater in the engine house to an open Cochrane heater located at a high point in the boiler house, whence it flows by gravity to the water weigher, which is on a level with the top of the boilers. From this weigher the water is discharged by gravity to an 8x20-ft. coagulating tank and a filter below on the boiler-room floor, from which the feed pump receives its supply. The feed water goes to the boilers at a temperature of from 190 to 200 deg. F.

At each discharge of the weigher a small pump on the boiler-compound tank which is shown at the left in Fig. 7 is operated by means of an arrangement of levers and a definite quantity of the compound is injected into the water while the latter is being discharged.

Water is purchased from the city and after passing through the city meters is distributed by a 10-in. Worthington centrifugal pump, driven by a 165-hp. Curtis horizontal single-stage non-condensing turbine at a speed of 2000 r.p.m. The pump-discharge pressure varies from 80 to 100 lb.

Mixed-Pressure Turbine

Refrigeration is provided by five De La Vergne double-acting compressors, three rated at 170 and two at 220 tons. All are driven by horizontal Corliss engines. The exhaust from the 36x36-in. steam ends of the two larger machines is used in a Curtis mixed-pressure turbine to drive a 500-kw. direct-current generator, Fig. 8. If needed, the exhaust from the 32x36-in. steam ends of the three smaller machines may also be supplied to the turbine through a bypass. Ordinarily, however, these operate condensing. In order to be able to change from condensing to non-condensing operation easily and quickly, Mr. Koedding has fitted an adjusting mechanism into the rods connecting the exhaust valves and wristplate on all the machines so that the length of these rods may be changed without shutting down.

This turbo-generator operates at a speed of 1500 r.p.m. and produces direct current for three-wire distribution at 250 and 125 volts. Its installation has eliminated the use of three 200-kw. vertical-compound condensing Corliss engines and effected a marked economy in the overall steam consumption of the plant.

In addition to the rather complete equipment of instruments for securing boiler economy the plant is fitted with General Electric steam-flow meters for measuring the steam supplied to the various departments. There is also a portable recording-flow meter for testing and checking the demands of the different departments, and a portable indicating-flow meter for testing any piece of steam-consuming apparatus when desired.

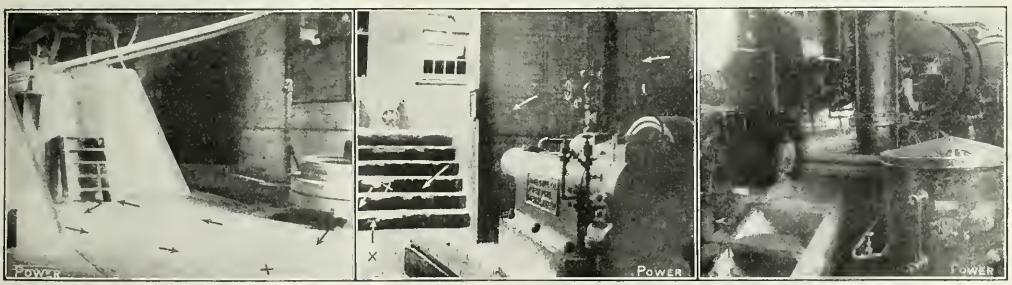
Any changes made in the design or equipment of the plant are decided upon and worked out by an engineering board consisting of Wm. J. Lemp, president of the company, who is a mechanical engineer, J. T. Norton, architect, and Wm. Koedding, master mechanic. The operation of the plant is under the direct supervision of the last named.

Turbine Rotor Climbs Stairs

It is not every turbine rotor that performs the phenomenal feat of bursting through its casing, jumping over an air compressor and climbing stairs leading into the yard, all in one nonstop dash. Yet a 100-kw. De Laval impulse turbine in the plant of the Alpha Portland Cement Co., Phillipsburg, N. J., claims this distinction.

Determined to preserve the reputation it thus established it endeavored to try it all over again about two weeks after the first "break."

This is how it happened: The machine, whose normal speed was 9000 r.p.m., drove two small generators through gears. Due to some cause, not explained, the speed became excessive. The rotor burst through the casing, knocked away a 6-in. exhaust pipe, leaped over a small air compressor onto the floor in front of the cement stairs leading out of the engine room. From here it darted for the stairs, successfully climbing them until it reached the third step, where, owing to its excessive speed, it lost its toe hold and ground out about 5 in. of the step before turning back into the room previous to a 35-ft. lunge into an inoffensive foundation. Wheeling quickly to the home stretch it crashed into another similar foun-



Arrows Indicate the Course Taken by the Rotor of the Turbine at the Right

The exhaust-steam supply line to the turbine is equipped with a large Cochrane oil-and-water separator having a capacity of 50,000 lb. per hr. Normally, the steam enters the turbine at a vacuum of about 3 in. of mercury and discharges into a vacuum of 27 or 28 in. developed by two Alberger surface condensers of 3000 sq.ft. each. The condensed steam is used in a 250-ton can ice plant. The live-steam supply to the turbine is cut in automatically when the available exhaust steam becomes insufficient.

dation 10 ft. away and then sped across the floor nearly to the starting point.

The arrows in the photographs show the route taken by the rotor. When the machine received the necessary repairs, and about two weeks after this startling piece of misbehavior, it again sought liberty by endeavoring to do the stunt over again and would have succeeded but for the presence of the engineer who foiled it by shutting off the steam.

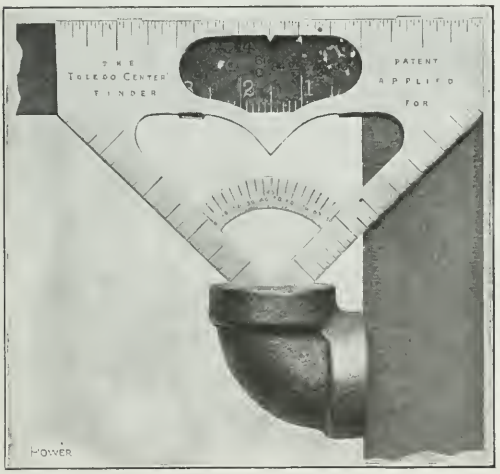
The second accident was caused by a defective gear shaft, which broke. The effect was like an increase of load and the governor on the opposite shaft, operated to admit more steam. Before the speed became damaging the engineer shut off the steam.

Examination of the shaft showed that it was hollow for at least 9 in. of its length. The break occurred 4 in. from the flange on the generator end. The cracks or hollow extending into the shaft about 2¼ in. The cracks in the other end, which was bent nearly U-shape, were much deeper, being about 6¾ in.

The cross-sectional area of the shaft was reduced so much as to allow for no undue strains, and it would appear that a sudden increase of load snapped the shaft. Fortunately, no one was injured in either accident.

Toledo Center Finder

This tool is made to use with a carpenter's steel square, as illustrated, when it will readily determine the center measurement of pipe fittings; it covers a range of sizes from 1 to 6 in. It is made of steel, with a ground face. Each straight-edge is graduated, one edge is $\frac{1}{16}$ in., one



Toledo Center Finder

⅛ in., and one is ¼ in. The cross brace of the finder forms an arc of a circle and serves as a protractor, being graduated down to 5 deg.

In addition to its use as a center finder, the instrument can be used for striking correct angles and inclinations in laying out piping.

The method employed to find the center of a fitting is to hold the same true against the wide tine of the square and push up against the finder, which will slide one way or the other on the square until it seats itself in the fitting. The pointer on the finder will then show the measurement desired. The finder is made by the Toledo Pipe Threading Machine Co., Toledo, Ohio.

Improved Falls Engine Stop

The improvement recently made to this engine stop is confined to the arrangement of the front-head mechanism, whereby the solenoid is mounted in the upper half

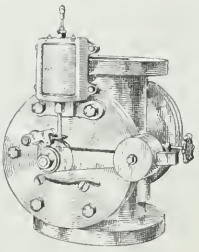


Fig. 1. Solenoid on Valve

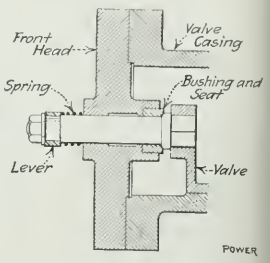


Fig. 2. Packingless Stuffing-Box

of the valve, Fig. 1, and to the simplified speed-limit band in which the pivoted bearing has been done away with. An improvement has also been made by the manufacturer, the Falls Machine Co., Sheboygan Falls, Wis.,

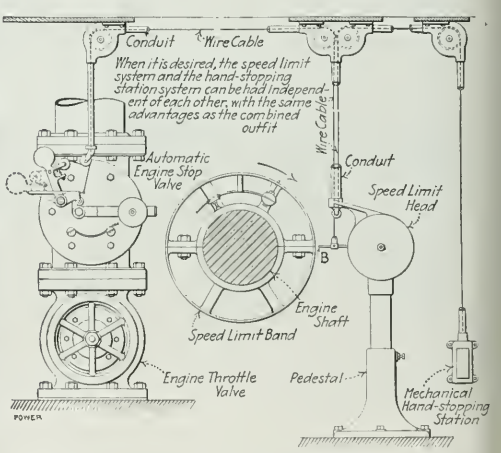


Fig. 3. Stop Valve, Speed-Limit Band and Connections

in the elimination of the stuffing-box in the front head of the valve, as the joint has been made packingless. Fig. 2. The steam pressure inside the valve-stem shoulder acts against the squared end of the valve stem and holds it firmly seated against the valve-stem bushing and seat. The contact face on the valve-stem shoulder is curvilinear, its corresponding seat in the valve-stem bush-

ing being of a straight bevel form. The two faces are lapped together to form a ground joint, which eliminates leakage of steam.

Referring to Fig. 3, which shows the speed-limit band, should the cable break at any point the weight lever on the front head is released, which action occurs if the stop is operated from a hand stopping station or by the speed-limit band.

Pacific Mills Coal- and Ash-Handling Equipment

SYNOPSIS—A coal- and ash-handling system, consisting of three distinct parts. The first is a pivoted bucket conveyor to transfer the coal from the cars to the coal bunkers. The second part consists of charging cars for conveying coal from the bunkers to the boiler room, and the third part is an industrial railway system for removing ashes.

The completeness of the coal- and ash-handling apparatus in the power plant of the new print works of the Pacific Mills, South Lawrence, Mass., shows that large industrial plants appreciate that economy can be obtained by employing uptodate apparatus in the power plant as well as by the use of improved machinery in the manufacturing departments.

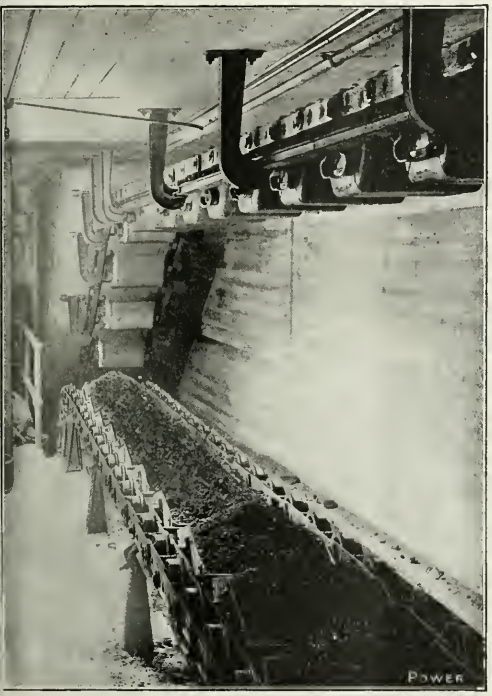


FIG. 1. PIVOTED BUCKET CONVEYOR

There are three distinct parts to this equipment. The first consists of a pivoted-bucket conveyor which receives the coal from the railroad cars and distributes it into the storage pocket. In addition to this conveyor a motor-driven car distributes coal to parts of the storage pocket not reached by the conveyor. The second part, consisting of charging cars and an industrial railway, is used to convey coal from the storage pocket to the boiler room. The third part, consisting of another industrial railway system, is for the removal of ashes.

Coal is brought to the plant in railroad cars of the bottom-dumping type and is distributed into a pit under the track. It then passes into an electrically driven coal cracker, which breaks up the large chunks of bituminous coal into lumps of proper size for firing. The coal cracker discharges through a revolving filler to a pivoted-bucket conveyor which runs through the tunnel, shown in Fig. 1, and then rises, as shown in the rear of Fig. 2, and carries coal to the distributing chutes, each of which is provided with an automatic trip so that the coal can be discharged from the conveyor buckets into any chute desired.

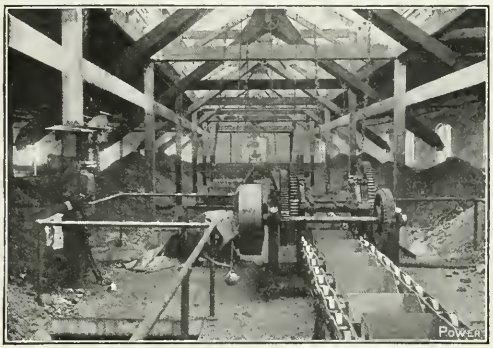


FIG. 2. TOP OF COAL BIN, VERTICAL-RUN CONVEYOR AND EMPTY RETURN BUCKETS

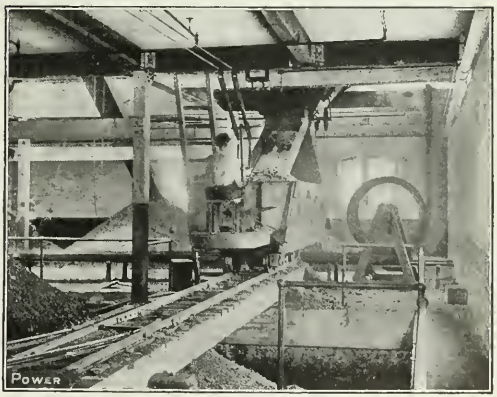


FIG. 3. ELECTRICALLY DRIVEN DUMP CAR

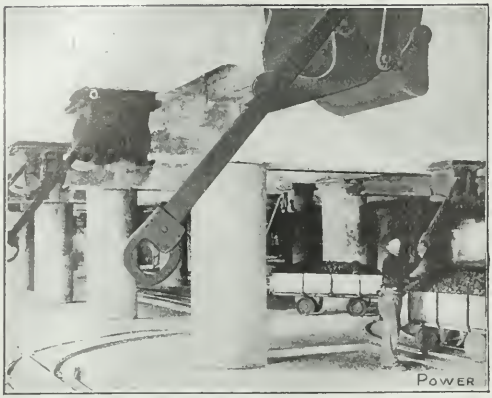


FIG. 4. BOILER-ROOM CHARGING CAR AND LOADING HOPPERS

The motor-driven conveyor driver is located on the upper level. The conveyor is driven by an open-geared pawl driver.

Besides the coal pocket shown in Fig. 2, there is an auxiliary row of storage bins at the extreme left of the building. For filling these bins, the conveyor can be arranged to discharge into an auxiliary hopper, Fig. 3, which is used for filling an electrically operated car of 2-ton capacity, running on a track over the storage bins.

The bins have a combined capacity of 10,000 tons of coal, but are so subdivided that the individual bins can

FIG. 5. WEIGHING THE COAL

be emptied in a few minutes in case the coal commences to heat and there is danger of spontaneous combustion.

Taking up the second part of the system; from the bins shown in Fig. 2, the coal is drawn off through duplex valves into boiler-room charging cars, as shown in Fig. 4. Although these cars are of 1-ton capacity, they can be filled in a very short time—less than a minute.

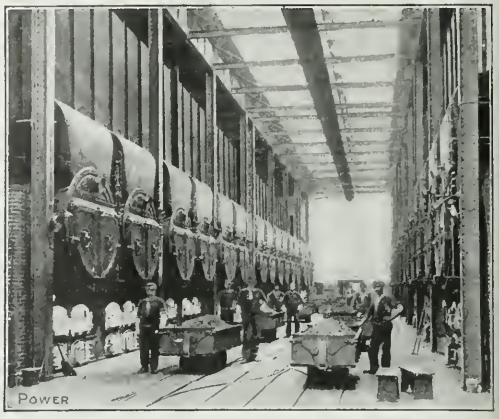


FIG. 6. CHARGING CARS IN FRONT OF BOILERS

The charging cars are pushed by hand onto the scales, Fig. 5, and a record of all the coal burned is kept. The cars are then pushed into the boiler room, as shown in Fig. 6. The two outside tracks are so located that the fireman merely drops the side of the car and shovels the coal into the furnace. The middle track is provided for shunting out empties and running in full cars.

These coal cars are designed especially to facilitate firing the coal into boiler furnaces. They are made of sheet steel, stiffened with angle iron, the corners rounded off for the workmen's hands and the bottom flush riveted. When the side door is let down, its bottom is slightly higher than the floor of the car, so that the fireman will not catch his shovel when scooping up the coal.

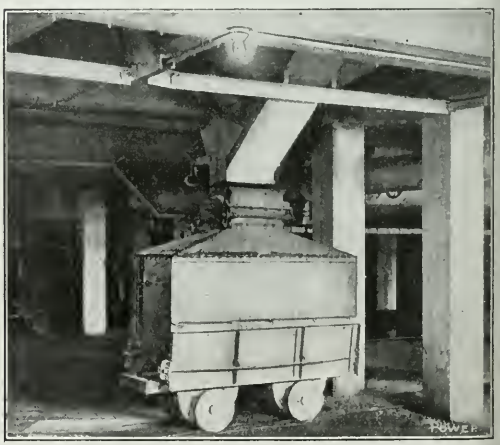


FIG. 7. ASH CAR AND ASH CHUTE

This completes the coal-handling equipment which has a capacity of 60 to 70 tons an hour, more than ample to keep the 30 boilers supplied when running at full capacity.

Fig. 7 shows the room underneath the boilers, for the removal of ashes. The ash car has been designed so as to be practically dust-proof. As soon as the car is run

under the ash hopper, a lever at the top of the car is pulled down and a telescoping spout on the car is shoved up and encircles the bottom of the ash hopper, thus preventing ashes from flying around.

This coal- and ash-handling system was designed by Lockwood, Greene & Co.; the apparatus, including the conveyors, charging and ash cars, motor-driven coal car, coal and ash valves, trackage, etc., used in this equipment, was supplied by the C. W. Hunt Co., Inc., West New Brighton, N. Y. The cars have outside-flanged wheels, permitting one man to easily push a 1-ton load around a curve of 12 ft. radius, as in taking the curves the outside wheels run on their flanges so that the tread of the inner wheel and the flange of the outer one fall upon the theoretical cone of revolution.

Maihak Indicator and Boettcher Efficiency Indicator

The Maihak indicator, Fig. 1, is designed to be used especially with gas and Diesel oil engines. It is reliable up to 600 r.p.m. and is fitted with a piston one-fifth the area of the normal piston.

The spring support through which the piston rod passes centrally forms the cylinder cover and also the turntable for the pencil link work.

The indicator is convertible from a right-handed to a left-handed instrument. The link attachment, piston and spring may be instantly removed. The piston rod is hollow and removable. The pencil lever has a magnifying ratio of 6 to 1 and the link gives a practical straight line motion. The indicating link work is a modification of the pantograph.

A double spring is used and is arranged to operate in tension, instead of compression. The two spirals forming the spring are screwed into a base formed in two parts and rigidly fastened.

The drum is controlled by a spiral spring and is fitted with a double cord whereby two indicators may be coupled together by a common reducing link work. It is fitted with a friction clutch to facilitate connecting the cord to the reducing motion.

The indicator may be fitted with a Böttcher's efficiency reckoner, by means of which the mean indicated efficiency of the engine may be found by reading a counting instrument and multiplying by a constant. The reckoner takes account of every stroke of the engine and counts every diagram taken; the indicator can be used with or without the instrument.

Referring to Figs. 2 and 3 the reckoner is supported on a pillar *A*. The counting roller *E*, in the frame *D*, on the upper front surface of the indicator drum, is pushed to and fro in a radial direction on top of the paper drum by a lever *C*. A spring *F* presses the roller against the upper surface with a known pressure of adhesion. Upon the roller spindle a worm gear is mounted which transmits the motion to a simple set of spur wheels capable of registering a number of observations extending over a long period.

The travel of the periphery of the counterspool is directly proportioned to the average pressure indicated, and this records the power expended. To find the mean pressure exerted during a definite period of time, a revolution counter must be read in addition to the pressure counter, but if the average indicated horsepower is to be ascertained it is not necessary to use a revolution counter.

These instruments are put on the market in this country by Herman Bacharach, 1009 Hartje Bldg., 11 Wood St., Pittsburgh, Penn.

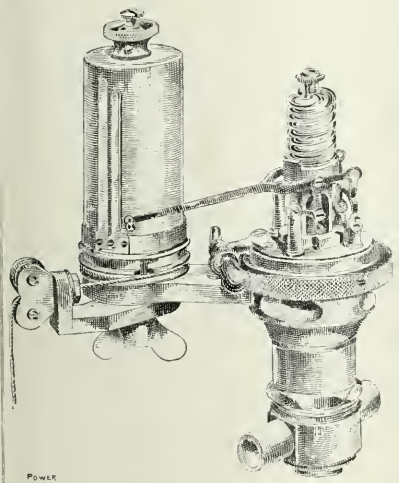


Fig. 1. Maihak Indicator for Gas and Oil Engines

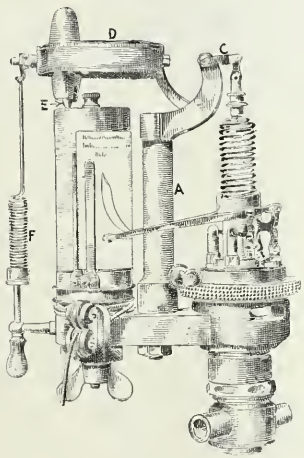


Fig. 2. Counter in Operative Position

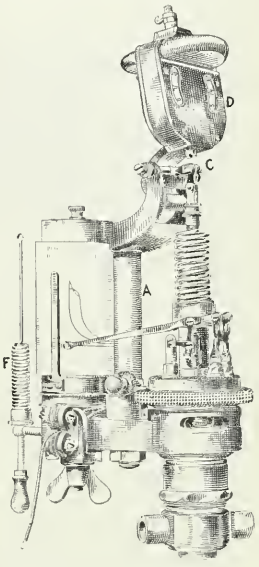


Fig. 3. Counter in Lifted Position

CO_2 Thermoscope

An instrument for ascertaining the quantity of CO_2 in the waste gases from a boiler furnace is shown in Fig. 1. The CO_2 thermoscope makes use of a well known principle of thermo chemistry, but one which has not heretofore been applied in the analysis of gases, viz., that chemical reactions are attended by change of temperature, and that the amount of heat either absorbed or disengaged is determined by the nature of the reaction, and the quantities of reagents which enter into combination.

When carbonic-acid gas (CO_2) either pure or in admixture with air is brought into contact with caustic soda a chemical reaction takes place, and heat is evolved, the amount of which is proportional to the quantity of CO_2.

If, therefore, a measured quantity of the gas mixture to be analyzed is brought into contact with caustic soda, the amount of which being somewhat more than sufficient to absorb all the CO_2 present, it is only necessary to measure the heat evolved to obtain a measure of the CO_2 in the mixture.

The caustic soda is prepared for use in hermetically sealed metallic cartridges, a fresh cartridge being em-

FIG. 1. CO_2 THERMOSCOPE

ployed for each analysis. The heat reaction is produced by passing a known quantity of the gas mixture to be analyzed through the contents of the cartridge, while the amount of heat disengaged is measured by means of a specially constructed calorimeter thermometer using a scale empirically calibrated in percentages of CO_2.

With the exception of two thermometers the instrument is made of brass and hardwood. It is strongly made and will stand hard usage. It is 10 in. in length and 2 in. in diameter and may be carried in the pocket. Thus an engineer with a few cartridges in one pocket and the CO_2 thermoscope in the other, and without the necessity of setting up and adjusting any apparatus can obtain analysis of the CO_2 from a range of boilers quickly.

After it has been used the instrument requires no washing or cleaning. It is just put back into its leather case and is ready again for instant use the next day or the next month as the case may be.

The instrument consists of three essential parts. A cylinder is fitted with a plunger for drawing a measured quantity of the mixture from the flue or chamber containing the gas mixture, and subsequently passing it through a cartridge-shaped receptacle containing pulverized caustic soda in which the heat reaction occurs. There is also a thermometer with its bulb constructed to surround or jacket the cartridge, so that the heat of reaction can be imparted to the mercury, the amount of its expansion, i.e., the percentage of CO_2 to be observed on a movable scale.

By reference to Fig. 2 it will be seen that B is a cylinder fitted with a piston and cup leathers. The thermometer E is conveniently mounted on the cylinder, and the whole is inclosed by the outer cylindrical metallic jacket A, which is slotted to show the stem of the thermometer. A movable scale F calibrated in percentages of CO_2, is arranged to slide in the slot. D is a cartridge of thin sheet metal containing the pulverized caustic soda, and

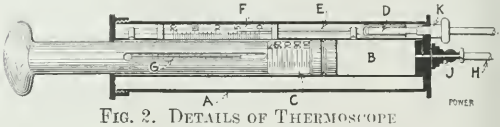


FIG. 2. DETAILS OF THERMOSCOPE

is shown jacketed by the thermometer bulb in position for analysis.

Connection is made between the cylinder and cartridge by means of the rubber tube K and H, the latter being attached to the tap J.

In order to correct the volume of the gas taken into the cylinder for varying room temperatures, the length of travel of the piston is regulated according to the temperature, as shown on the thermometer G by the scale C engraved on the piston rod.

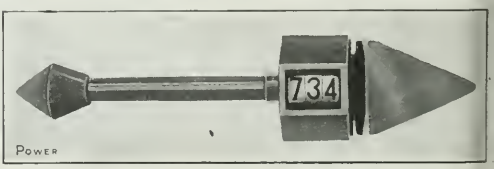
When about to make an analysis a cartridge is pricked at each end to enable the gas to flow through it. It is then attached to the rubber connection and inserted in the thermometer bulb. A sample of gas is drawn into the cylinder, the necessary temperature correction being made, and the free end of the rubber tube is connected to the cylinder nozzle. The zero of the movable scale is adjusted opposite the top of the mercury column of the thermometer and the piston rod is depressed. The gas mixture flows through the cartridge, heat is generated, the mercury rises, and opposite the highest point reached by the rising column may be read from the scale in plain figures the percentage of CO_2. The reading of the instrument may be taken in any position.

The CO_2 thermoscope is manufactured by the Underfeed Stoker Co., Ltd., of Coventry House, South Place, London.

⁂

Vest-Pocket Shaft-Speed Counter

A neat little speed counter, suitable for carrying in a vest pocket, is illustrated herewith. The counter reads right or left. One end is made with a metal arrow point for cleaning out the counter-sunk end of a shaft of any accumulation of dirt or oil. The end of the counter spindle is applied to the center of the shaft.



VEST-POCKET SPEED COUNTER

It is not necessary to start the readings with zero, as it is only necessary to deduct the initial reading from the final result, which will give the number of revolutions per minute. The counter is made by the American Steam Gauge and Valve Manufacturing Co., Camden St., Boston, Mass., and sold at a moderate price.

ELECTRICAL DEPARTMENT

Transformer Characteristics

By Edward T. Moore*

A transformer should be rated by its kilovolt-ampere (kv.-a.) output. If it is supplying a load having a power factor of 100 per cent., the kilowatt output will be the same as the kilovolt-ampere output. If, however, it is supplying a load having a power factor less than 100 per cent., the kilowatt output will be less than the kilovolt-ampere output in the ratio that the power factor is less than 100 per cent. For example, a transformer having a full-load rating of 100 kv.-a. will have a full-load rating of 100 kw. at 100 per cent. power factor, 90 kw. at 90 per cent. power factor, 80 kw. at 80 per cent. power factor, etc.

Ratings for Special Groupings

For certain groupings of single-phase transformers on polyphase circuits, the rating of the group is less than the sum of the single-phase ratings of the individual transformers composing the group. This point can be readily understood by reference to the following illustrations: the first two cases of delta and star connections, being very familiar, are given merely as explanatory steps to the other cases. For a three-phase circuit, assume the following general conditions:

Line voltage $= E$.

Line current $= \sqrt{3}\, I = 1.73\, I$.

Total kv.-a. to be transformed $= 1.73\, IE\, \sqrt{3} = 3\, IE$.

1 to 1 ratio of transformation.

1. Three transformers delta-connected, assuming each transformer to have a capacity $= \frac{3\, EI}{3} = EI$ kilovolt-amperes.

Transformer voltage = line voltage $= E$. (See Fig. 1).

Transformer current = line current $\div 1.73 = I$.

Kilovolt-amperes in primary winding of each transformer EI.

The kilovolt-amperes in the secondary winding are the same. Therefore, the assumed single-phase rating that each single-phase transformer equals one-third the group rating, is correct.

2. Three transformers, star-connected, assuming each transformer to have a capacity of $\frac{3\, EI}{3} = EI$ kilovolt-amperes.

Transformer voltage = line voltage $\div 1.73 = \frac{E}{1.73}$ (See Fig. 2).

Transformer current = line current $= 1.73\, I$.

Kilovolt-amperes in primary winding of each transformer $= \frac{E}{1.73} \times 1.73\, I = EI$.

The kilovolt-amperes in the secondary winding are the same. Therefore, the assumed single-phase rating that each single-phase transformer equals one-third the group rating is correct.

3. Two transformers, V-connected, or open delta, for three-phase operation, assuming each transformer to have a capacity of $\frac{3\, EI}{2} = 1.5\, EI$.

Transformer voltage = line voltage $= E$. (See Fig. 3).

Transformer circuit = line current $= 1.73\, I$.

The kilovolt-amperes in the primary winding of each transformer $= 1.73\, EI$.

The kilovolt-amperes in the secondary winding are the same. Therefore, each transformer must carry $1.73\, EI$ kilovolt-amperes in order to deliver $1.5\, EI$ kilovolt-amperes to the secondary circuit. Therefore, the single-phase rating of each single-phase transformer must be 1.155 times one-half the group rating.

4. Two transformers, T-connected, assuming each transformer to have a capacity of $\frac{3\, EI}{2} = 1.5\, EI$ kilovolt-amperes.

Main transformer voltage = line voltage. (See Fig. 4).

Main transformer current = line current $= 1.73\, I$.

The kilovolt-amperes in the primary winding $= 1.73\, EI$.

The kilovolt-amperes in the secondary winding are the same.

"Teaser" transformer voltage $= 0.866 \times$ line voltage $= 0.866\, E$.

"Teaser" transformer current = line current $= 1.73\, I$.

The kilovolt-amperes in the primary winding of teaser $= 1.73\, I \times 0.866\, E = 1.5\, EI$.

The kilovolt-amperes in the secondary winding are the same.

Although the kilovolt-amperes in the "teaser" transformer windings are $1.5\, EI$, the excess current in the windings is the same as in the main transformer windings, as duplicate transformers are used and the currents in each are equal. This shows that the main transformer must carry $1.73\, EI$ kilovolt-amperes to deliver $1.5\, EI$ kilovolt-amperes and the "teaser" transformer $1.5\, EI$ kilovolt-amperes, but with excess current. Therefore, the single-phase ratings of each single-phase transformer must be 1.155 times one-half the group rating.

5. Two transformers connected for three-phase to two-phase operation, assuming each transformer to have a capacity $= \frac{3\, EI}{2} = 1.5\, EI$.

Main transformer voltage = line voltage $= E$. (See Fig. 5).

Main transformer current = line current $= 1.73\, I$.

Kilovolt-amperes in primary of main transformer winding $= 1.73\, EI$.

*Electrical engineer, Westinghouse Electric & Manufacturing Co.

"Teaser" transformer voltage = 0.866 × line voltage = 0.866 *E*.

"Teaser" transformer current = line current = 1.73 *I*.

The kilovolt-amperes on the primary side of the "teaser" transformer is 1.73 × 0.866 *E* = 1.5 *EI*, but there is an excess current in the windings equal to that in the main transformer, as the transformers are duplicates and the currents in each are equal. The main transformer, therefore, carries 1.73 *EI* kilovolt-amperes in the primary or three-phase winding to deliver 1.5 *EI* kilovolt-amperes, and the "teaser" transformer 1.5 *EI* kilovolt-amperes, but with excess current (1.73 *I* × 0.866 *E* = 1.5 *EI*). Therefore, the single-phase rating of each single-phase transformer must be 1.155 times one-half the group rating if based on the average of the current in both the three-phase and two-phase windings.

1.0775 times one-third the group rating if based on the average of the currents in both the primary and secondary windings.

The foregoing can be summed up as follows:

1. *Three single-phase transformers, delta-connected*—The sum of the single-phase ratings equals the group rating.

2. *Three single-phase transformers, star-connected*—The sum of the single-phase ratings equals the group rating.

3. *Two single-phase transformers, V-connected*—The sum of the single-phase ratings is 15½ per cent. greater than the group rating.

4. *Two single-phase transformers, T-connected*—The sum of the single-phase ratings is 15½ per cent. greater than the group rating.

5. *Two single-phase transformers connected for three-*

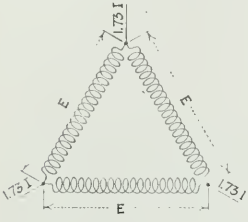


FIG. 1

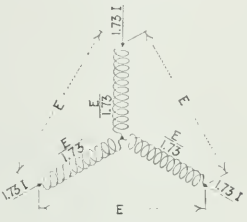


FIG. 2

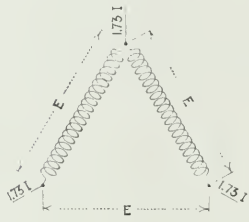


FIG. 3

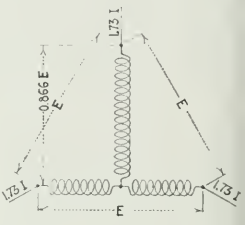


FIG. 4

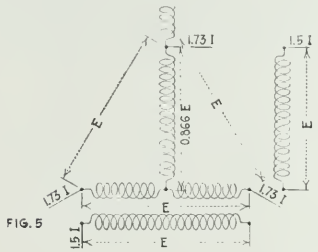


FIG. 5

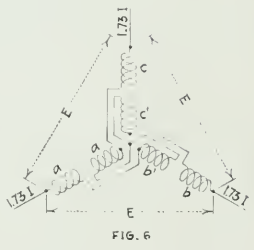


FIG. 6

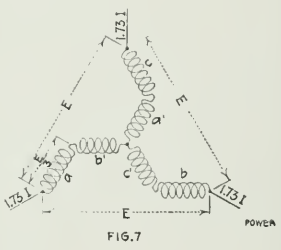


FIG. 7

Diagrams of Different Transformer Connections

6. Three transformers with the secondary windings connected in interconnected star for operating a three-wire, direct-current, three-phase rotary converter assuming each transformer to have a capacity of $\frac{3}{3} EI = EI$.

The primary side of the transformer will be delta or star connected and the conditions will be normal, as given in cases 1 and 2. The secondary will be connected as shown in Fig. 6, the current and voltage relations being shown in Fig. 7. Note that the secondary winding of each transformer is divided into two parts, each part wound for a voltage of $\frac{E}{3}$.

Transformer voltage = ⅔ line voltage = ⅔ *E*.

Transformer current = line current = 1.73 *I*.

Kilovolt-amperes in winding = ⅔ *E* × 1.73 *I* = 1.155 *EI*.

Each secondary winding is therefore carrying 1.155 *EI* kilovolt-amperes in order to deliver *EI* kilovolt-amperes. Therefore, the single-phase rating of each single-phase transformer must be 1.155 times one-third the group rating if based on the current in the secondary winding or *phase to two-phase transformation*—The sum of the single-phase ratings is 15½ per cent. greater than the group rating if based on current in the windings connected three-phase, or 7¾ per cent. greater if based on the average of the currents in both the three-phase and two-phase windings. Two standard single-phase transformers for such service should have a total capacity 15½ per cent. in excess of the group rating.

6. *Three single-phase transformers with one winding connected in interconnected star*—The sum of the single-phase ratings is 15½ per cent. greater than the group rating if based on current in the windings connected in interconnected star or 7¾ per cent. greater if based on the average of the currents in both the interconnected star windings and the delta or star-connected windings. Three standard single-phase transformers for such service should have a total capacity 15½ per cent. in excess of the group rating.

Assuming that 300 kv.-a. are transformed in each of the cases given, the single-phase ratings of the individual transformers should be as follows:

1. 100 kv.-a. (3 required).

2. 173.5 kv.-a. (2 required).
3. 173.5 kv.-a. (2 required).
4. 100 kv.-a. (3 required).
5. 173.5 kv.-a. (2 required).
6. 115.5 kv.-a. (3 required).

Transformers are usually specially designed for the last two cases (5 and 6) and have increased capacity in the three-phase or interconnected star winding only. When operating such transformers single phase, the lighter loading determines the capacity of the transformer.

Ratings for Operation of Rotary Converters and Motors

In specifying transformers for the operation of rotary converters and motors, the apparent efficiency of the apparatus must be considered. In general, the apparent efficiency of a rotary converter may be assumed as 90 per cent. so that, for example, if a rotary converter has an output of 300 kw., a transformer capacity of 333 kv.-a. will be required for operating it. This relation of transformer capacity to rotary converter capacity must always be adhered to.

The apparent efficiencies of motors vary widely, depending upon the size, frequency and speed but will generally vary from about 75 per cent. to 90 per cent. It is customary to allow 1 kv.-a. transformer capacity for each horsepower of the motor, excepting for large motors where the transformer capacity should be calculated from the efficiency and power factor of the motor.

Voltage Classes

Transformers are divided, according to high-tension voltages, into the following twelve classes: 6600, 11,000, 16,500, 22,000, 33,000, 44,000, 55,000, 66,000, 77,000, 88,000, 100,000 and 110,000. While these voltages are considered standard, transformers may be wound for any reasonable high-tension voltage desired. In specifying a transformer with a high-tension voltage other than one of those given in the above classification, note particularly that each voltage class indicates the highest voltage for which any transformer belonging to that class can be designed. For example, if a transformer is to be designed for 46,000 volts, it will belong to the 55,000-volt class and not to the 44,000-volt class.

In specifying single-phase transformers to be connected in star on a three-phase circuit, the line voltage and not the transformer voltage determines the voltage class to which the transformer belongs. An exception may be made to this in case the neutral point is to be connected directly and permanently to ground. The transformer voltage (the voltage from the neutral point to the line) may then be considered as determining the voltage class.

Voltage Taps

To compensate for line drop, standard taps are provided on both high-tension and low-tension windings to give voltages approximately 3, 6 and 9 per cent. below normal. For example, if a transformer is wound for a normal ratio of 33,000 to 2200 volts, taps are provided to give additional high-tension voltages of 32,000, 31,000 and 30,000 and additional low-tension voltages of 2130, 2070 and 2000. With this arrangement, seven different ratios of transformation are obtainable, as shown in the following table:

16 5—1	16—1	15 5—1	15—1	14 5—1	14—1	13.5—1
36,300	33,000	33,000	33,000	32,000	31,000	30,000
2,200	2,070	2,130	2,200	2,200	2,200	2,200
	32,000	32,000	32,000	31,000	30,000	
	2,000	2,070	2,130	2,130	2,130	
		31,000	31,000	30,000		
		2,000	2,070	2,070		
			30,000			
			2,000			

From this it will be seen that if two transformers are connected to a transmission line, one as a step-up and the other as a step-down transformer, a total voltage drop of approximately 18 per cent. can be compensated for. Taking the case referred to above, with an impressed voltage of 2200 on the primary of the step-up transformer, and with the ratio of transformation of 1 to 16.5, the voltage delivered to the line will be 36,300, and by using the 13.5 to 1 ratio on the step-down transformer, a voltage of 30,000 impressed on the primary will deliver normal voltage of 2200 at the second terminals. That is, the two transformers together are able to compensate for a line drop of 6300 volts and still deliver normal voltage at the receiving end.

Parallel Operation

Transformers should never be connected together for parallel operation unless the individual transformers comprising the group are built under the same specification and are, therefore, alike. If it is ever necessary to operate unlike transformers in parallel, paralleling coils must be employed or impedance coils placed in the circuits of the transformer having the lower impedance. Paralleling coils are similar to balancing coils in construction and should be used in preference to impedance coils wherever possible, as they can be used in nearly all cases except when operating conditions are not permanent. For example, where one bank of transformers having certain characteristics is to be operated in parallel with two, three or more banks of transformers which are alike in themselves but differ in characteristics from the single bank, such a condition would require a paralleling coil with several taps, necessitating more or less expensive switching apparatus. In such cases, impedance coils are necessary.

(*To be concluded*)

❖

Interconnected Large Power Systems—An indication of the line of thought which is being actively pursued in America can be gained from noting what is really happening in this country, in a territory where a network is being set up which is already within measurable distance of the ideal forecasted by Edison, Ferranti and Steinmetz—no small fry here, no duplication and multiplication of buildings, boilers, bunkers, boosters and busbars, but a few giant steam and hydraulic stations turning out their load according to a real schedule of conservation. . . . The economical operation of such systems as the Southern Power Co., a large network in itself, which is tied in with the Yadkin River Power Co., at Method, and is contemplating tying in with the Georgia Power Co., at Easley, and the latter with the Tennessee Power Co., at Rome, is a problem of considerable importance. The Southern Power Co. is operating approximately 350 miles of 100,000-volt lines as well as an extensive network of 44,000-volt and 11,000-volt lines, and the Yadkin River Power Co. has approximately 190 miles of 100,000-volt lines. The Georgia Power Co. will have approximately 200 miles of 100,000-volt lines, and the Tennessee Power Co. nearly 200 miles of 120,000-volt lines, as well as approximately 100 miles of 66,000-volt lines, making a total of nearly 800 miles of 100,000-volt lines in the four systems, and hundreds of miles of lower voltage lines, all tied in one vast system. The total distance by transmission line from Blewetts Falls to Nashville will be over 700 miles.—"Electrical Review."

GAS POWER DEPARTMENT

Gasoline-Engine Troubles and Their Symptoms

By A. L. Brennan, Jr.

Since nearly all gas- or gasoline-engine difficulties are indicated by some form of symptoms an operator should first of all become thoroughly familiar with his motor from this standpoint. Suppose an engine refuses to start, this may be caused by any one of the following:

1. Lack of fuel.
2. Flooded motor.
3. Water in cylinder or carburetor.
4. Dirty spark plugs or igniters.
5. Short- or open-circuit in the ignition system.
6. Poor compression.
7. Carburetor out of adjustment.

If the ignition and carburetion are known to be in good adjustment, yet the motor fails to start, this would indicate that some of the mechanical features are at fault. In this case the motor should be cranked over with all the relief valves closed in order to test the compression. If considerable resistance is encountered on the compression stroke without any binding, the compression is evidently all right. But if the piston moves up without meeting much resistance it is an indication that the compressed gas is escaping, which may be due to dry or scored cylinders, worn piston rings, faulty valves or valves out of time, partly open compression cocks or defective gaskets.

Ignition circuits are easily tested by removing the spark plugs, reconnecting the high-tension wires and placing the threaded portion of the plug on the cylinder; then place the switch in position and crank the motor over to the firing point of each cylinder and note if a bright spark appears between the points of the spark plugs. It should be remembered that a spark produced under ordinary conditions will have to be quite strong or it will prove inadequate when subjected to the high compression within the cylinder.

The only way to find out if a carburetor is properly adjusted is to make sure first that the controlling or mechanical features of the motor are in good order and that the ignition is all right; then attempt to start and note the symptoms.

Carburetors are an auxiliary feature of a gas engine; however, they do not generate the mixture independently of the motor as is commonly supposed, but are directly dependent upon the action of the piston. That is, on the intake stroke, the piston creates a partial vacuum within the cylinder which produces a suction through the carburetor, thus mixing the fuel and air together and drawing a charge into the cylinder. From this it is quite evident that any mechanical failures, such as leaky valves, etc., that interfere with good compression will also militate against good vacuum pulling; hence impaired carburetion.

When an attempt is made to start a motor and it refuses to go, it is generally advisable to resort to priming; that is, injecting a little fuel into the cylinders and again cranking the motor. If it then starts but stops, accompanied by back-firing, this is a positive sign that the mixture is too weak. On the other hand, if the motor continues in operation but runs in a sluggish manner it would indicate an over-rich mixture. When a motor operates in a regular manner, but does not develop high efficiency it may be due to:

1. Faulty carburetor regulation.
2. Fuel of low grade.
3. Inefficient or insufficient lubrication.
4. Poor compression.
5. Exhaust partly choked up.
6. Ignition out of time.
7. Coils (high tension) out of adjustment.

Sometimes an engine will not develop its full power, due to being "choked up," that is, the throttle has been open too wide when the load was applied and the engine has failed to clear itself. The remedy is to disengage the load and allow the motor to speed up several times.

Misfiring and other irregular operation may be caused by:

1. Faulty carburetion.
2. Water in the carburetor.
3. Dirty or cracked spark plugs.
4. Poorly adjusted coils.
5. Dirty contacts on the vibrator.
6. Weak batteries.
7. Loose wires.

When the misfiring is general in all cylinders, it may be due to water in the carburetor or a loose battery connection; but, on the other hand, if the skipping is confined to a single cylinder it is probably due to a dirty spark plug or a loose connection in the secondary circuit, for if it was caused by dirt in the carburetor, for instance, the other cylinders would miss as well.

When a motor slows down and stops, especially when accompanied by backfiring, it indicates a shortage of fuel; while sudden stopping more often results from a broken or disconnected wire, stuck timer points, trembler on coil stuck or in rare cases to sudden exhaustion of the fuel or to the needle valve becoming clogged.

Explosions in the exhaust are in some cases due to one cylinder misfiring and exhausting unburned gas into the exhaust pipe where it comes in contact with the flames from the other cylinders and ignites. It is also caused by faulty exhaust valves, or to a slow-burning mixture, inefficient spark or to an over-retarded spark.

Overheating is usually due to insufficient circulating water, retarded circulation, an over-rich mixture or to continued operation on a retarded spark.

Hissing sounds invariably indicate air or gas escaping under pressure. This may be due to loose or defective spark plugs or igniters, partly open compresion cocks or defective gaskets.

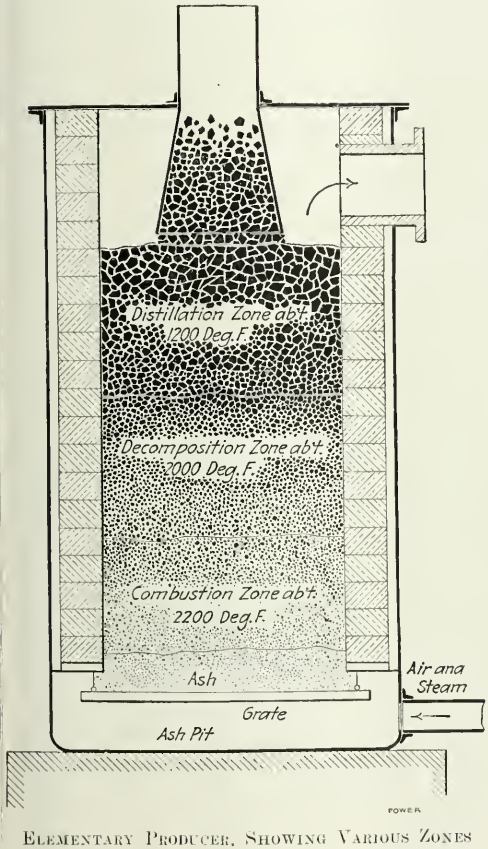
Knocking or pounding has two causes: mechanical and

functional. The first has reference to any lost motion that may exist in the bearings through wear or otherwise. The second has to do with the conditions that govern operation; that is, knocking is caused by ignition taking place too early or to an over-rich mixture. Carbon deposits sometimes become incandescent, causing preignition which is similar to knocking induced by an over-advanced spark.

Gas-Producer Chemistry

By G. W. Muench

For the successful operation of a gas producer it is desirable that the operator have a working knowledge of the chemistry of combustion. A thorough study of chemistry is not necessary as he needs only to get acquainted with four or five elements and a few of their compounds



Elementary Producer, Showing Various Zones

in order to get a good knowledge of the actions that take place inside a gas producer.

The elements with which to become familiar are carbon (C), hydrogen (H_2), oxygen (O_2), and nitrogen (N_2). The compounds that concern producer work are mainly water (H_2O), marsh gas (CH_4), carbon dioxide (CO_2), carbon monoxide (CO), and a number of heavy hydro-carbons, of which ethylene (C_2H_4) is the most important. These heavy hydrocarbons may be considered under the head of illuminants. Carbon compounds are so numerous that a study of these constitutes a separate branch of chemistry.

Hydrogen is not found free except in very small quantities. It is produced in gas making through the dissociation of water by high heat. Due to its extreme lightness the heat units in a cubic foot are not as high as many other gases, but the heat evolved in burning a pound of hydrogen is more than any other of the simple gases.

Oxygen forms 23 per cent. by weight and 20.7 per cent. by volume of the air. It is a supporter of combustion and when present in producer gas indicates that air has been drawn in from the outside through leaks. However, the absence of free oxygen does not necessarily prove that there are no leaks, as all the oxygen may have combined with carbon and hydrogen to form compounds.

Nitrogen forms about 77 per cent. by weight and 79.3 per cent. by volume of the air. It is inert and will not support combustion; that is, it enters the producer as nitrogen and leaves as nitrogen.

Carbon dioxide (CO_2) is a compound consisting of two parts of oxygen to one part of carbon by weight. It will not burn since it is itself the product of combustion. Therefore, it is undesirable in producer gas.

Carbon monoxide (CO) should always be a prominent constituent of producer gas, and should be kept as high as possible. It is formed by the incomplete combustion of carbon. This is the poisonous constituent of producer gas, and being odorless is hard to detect in the atmosphere when leakage occurs into the room.

Marsh gas, or methane (CH_4) comes from the distillation of oil or coal at fairly high temperatures, also from the slow decay of animal and vegetable matter under water. It is the principal constituent of natural gas, is easily handled in the gas engine, and has a high heat value. The higher the percentage of marsh gas in producer gas, the better.

Illuminants or heavy hydrocarbons are formed by the distillation of oils, coal, fats, etc. These hydrocarbons give the gas its lighting qualities. However, they are not present in producer gas in quantities worth considering.

Producer gas is a mixed gas consisting of carbon dioxide, oxygen, carbon monoxide, marsh gas, hydrogen and nitrogen, and occasionally traces of illuminants. It is formed by passing air and steam through a rather deep bed of fuel. The oxygen of the air unites with the carbon of the coal to form carbon dioxide. This takes place in the lower layers of the fuel bed. As this carbon dioxide leaves the combustion zone, as the lower zone is called, it passes up through the less highly heated zone above, called the decomposition zone. Here the CO_2 takes up more carbon to form CO. These reactions are expressed chemically as follows:

$$C + O_2 = CO_2 \quad (\textit{Combustion zone})$$

$$CO_2 + C = 2\,CO \quad (\textit{Decomposition zone})$$

The nitrogen remains unchanged and passes through the fire mixing with the CO.

The steam upon passing through the fire is broken up into its two constituents, oxygen and hydrogen, and the hydrogen, without any further change passes on with the mixture. The oxygen, however, unites with the carbon in

the decomposition zone to form CO. The changes taking place are expressed in this manner:

$$2\,H_2O + heat = 2\,H_2 + O_2$$
$$2\,C + O_2 = 2\,CO$$

The two may be combined and written

$$H_2O + C = CO + H_2$$

The upper layers of fuel are called the distillation zone. Here the gases in the fresh fuel are distilled out by the heat of the gases coming from the lower zones. In this zone the marsh gas (CH_4) is formed from the volatile matter of the coal. Some hydrogen may also be formed here. These different zones and their approximate temperatures are shown in the illustration.

Having followed the formation of the gas, the chemical actions that take place in the engine will now be considered. In the mixing chamber the producer gas is mixed with the proper amount of air; the mixture is then drawn into the combustion chamber and there exploded. During the burning of the gases at the beginning of the expansion stroke the following chemical changes take place:

$$2\,CO + O_2 = 2\,CO_2$$
$$2\,H_2 + O_2 = 2\,H_2O$$
$$CH_4 + 2\,O_2 = 2\,H_2O + CO_2$$

The nitrogen again undergoes no change. The principal constituents of the engine exhaust are, therefore, CO_2 and N_2 with water vapor, and usually a little free O_2.

The quantity of heat produced by the complete combustion of various gases has been found by experiment, and the heat value of a mixture may be found from the heat values of the component gases and the percentage of each. When speaking of the heat value of a cubic foot of gas it is necessary to specify the conditions of temperature and pressure as these determine the actual weight, and therefore the heat, contained in a cubic foot. This standard condition is a temperature of 62 deg. and an atmospheric pressure corresponding to 30 in. of mercury.

The most accurate method of determining the heat value of a gas is by means of a calorimeter. But as these instruments are expensive and require considerable laboratory experience, they are beyond the reach of the ordinary operator. If, however, the gas mixture has been analyzed and the heat values of its component gases are known, it is a very simple matter to figure its heat value and get results near enough for practical purposes.

As stated before, producer gas is a mixture of a number of other gases. Some of these gases burn, others do not. In producer gas CO, CH_4, and H_2 are combustible; CO_2, O_2 and N_2 are noncombustible. By experiment the heat values of these combustible gases have been ascertained. As analyses of gases are almost invariably given by volume, when figuring the heat value it is necessary to know the heat value per cubic foot of these various combustible gases. These values can be got from any reliable book on this subject. The following figures are representative for the heat values of the three gases, which make up the combustible part of producer gas. The heat value in British thermal units per cubic foot for hydrogen may be taken as 327, for carbon monoxide 324, and for marsh gas 1013. Having an analysis of the gas, and the foregoing heat values of the combustible constituents, the heat value of the mixture is figured by multiplying the heat value of each constituent by the fraction of a cubic foot of that constituent present in a cubic foot of the mixture and by then adding all the heat values.

For example, let it be desired to figure the heat value of the following producer gas, which is the analysis of a sample taken from a lignite suction producer: CO_2, 3.9 per cent; O_2, 1.9 per cent; CO, 16.8 per cent; CH_4, 8.5 per cent; H_2, 10.8 per cent; N_2, 58.1 per cent.

$$CO = 324 \times 0.168 = 54.5$$
$$CH_4 = 1013 \times 0.085 = 86.1$$
$$H_2 = 327 \times 0.108 = 35.3$$
$$Total = 175.9\ B.t.u.\ per\ cu.ft.$$

The calculation shows how simple it is to figure the heat value of a gas, knowing its analysis. With some study and practice during his leisure hours it is within the operator's reach to learn how to analyze the gas himself. It is a very simple process to at least find the amount of CO_2, O_2 and CO present, especially with an Orsat or similar apparatus. Although this analysis is not enough to figure the heat value it gives a clue to the condition of the fire in the producer.

The analysis should show only a very small amount of CO_2. An excess of CO_2 in producer gas is evidence of wasteful combustion inside the producer, of too much air, or of too little fire, or too hot a fire.

Free oxygen in producer gas is evidence of air mixed after the gas has passed through the fire. Free oxygen cannot come from the blast, as it would be converted into CO. Carbon monoxide should be the prominent constituent of producer gas, and the higher the percentage present the better. So small a percentage of CO would be due to the same troubles that cause excess of CO_2.

Too much hydrogen is likely to cause premature ignition in the engine, a trouble which may cause serious results; therefore, the percentage of hydrogen must be kept within limits. An excess is due to too much steam being drawn through the fire.

Marsh gas (CH_4) is a valuable constituent of producer gas, as it has a high heat value; the more present the better. But should an analysis of the exhaust gases show the presence of CH_4, there is a great deficiency of air, as the combustion is incomplete.

Sticking Fuel Valve

In the operation of an 80-hp. oil engine, using crude oil, considerable trouble was experienced during a cold snap by the fuel valve sticking. The trouble was thought to be due to the viscosity of the oil, and the following scheme for preheating proved both cheap and effective.

Four 16-cp. incandescent lamps were placed around the copper feed pipe in close proximity to the valves and thoroughly covered with asbestos. Practically all of the energy put into the lamps was thus converted into heat and transferred to the copper pipe, which in turn heated the oil as it passed through.

Bisbee, Ariz. G. S. WILLS.

A Speed of 3310 r.p.m. for an automobile motor was established by the automobile testing plant of the Worcester Polytechnic Institute, Mass. The conditions under which the tests were made approximated, as closely as possible, actual duty on the road. A dynamometer indicated that the 20-hp. rating of the motor, a Studebaker, was reached at 1120 r.p.m. At 1900 r.p.m., 30 hp. was developed, and at 3310, the maximum 36 hp., equivalent to a speed of 89 mi. per hr. At about 3300 r.p.m. the power curve began to drop.

HEATING AND VENTILATION

Heat Transmission with Pipe Coils and Cast-Iron Heaters under Fan Blast Conditions*

A series of 14 tests made at the Institute of Thermal Research of the American Radiator Co., on pipe coils of standard make, with the 1-in. pipe spaced on 2¾-in. centers, were discussed by the author and for comparison

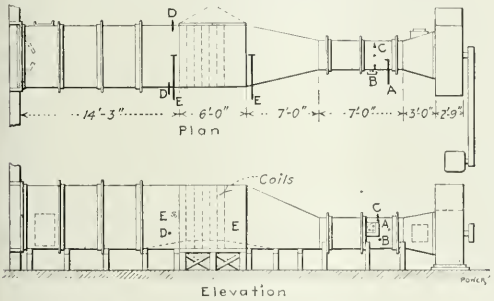


FIG. 1. PLAN AND ELEVATION OF TESTING APPARATUS

with the results equivalent values in Vento heaters were given. Tests were made on five sections, three sections and one section deep. Each section contained four staggered rows of pipe, making 193.1 sq.ft. of surface to each section, with a clear area for the passage of air of 17.06 sq.ft.

Steam was generated in cast-iron sectional boilers at pressures ranging from 9 to 18 lb. per sq. in. These pressures were reduced at the coils to a lower pressure ranging from 2 to 6 lb. per sq.in. The condensation was cooled and weighed in barrels. There was a steam separator in the high-pressure line and a similar one in the low-pressure line. Each coil was vented out of the return compartment on the same end of the coil where steam, return and bleeder connections were made. Each coil had individual valves on every connection. The bleeder header was looped into the return header. A steam-jacketed tank, with pressure equalized from the return header, served as a means of observing and regulating the flow of condensation out of the return pipe. The tests were started and stopped with the water level in the tank at a certain height, as shown by a string on the gage glass, so as to keep the bleeder loop sealed but leave the return header dry. The temperature of the steam was taken by a single calibrated thermometer and there was a similar thermometer on the return connection to each coil.

Before starting a test the coils were found to be hot all over. The variable-speed motor and dampers in the discharge piping provided means to obtain any desired velocity of air through the coils. Velocities were measured with a pitot tube and manometer, and these velocities agreed within an average of 6.65 per cent. of the velocities calculated from the amounts of condensation weighed. The velocities derived from the condensation values were used as test results since these results gave the total amount of heat taken out of the steam and therefore the maximum heating of the air. The velocities measured with the pitot tube were lower than those calculated out of doors from the face of the coils and a small amount of heat was radiated through the heater and the fan outlet,although all this sheet-steel work was covered 2 in. thick with hair felt. All the steam, return and bleeder headers and connections were also covered with hair felt.

With the pitot tube readings were taken at *A*, Fig. 1 on one horizontal, one vertical and two diagonal diameters, 10 readings on each diameter, thus making readings at 40 different points. These 40 readings were taken twice in an hour. The average velocity was calculated from these velocity-pressure readings and this velocity was reduced to its value for dry air at 70 deg temperature and 29.92 in. barometer, which is used as a standard. At *D* is shown the location of the cold-air

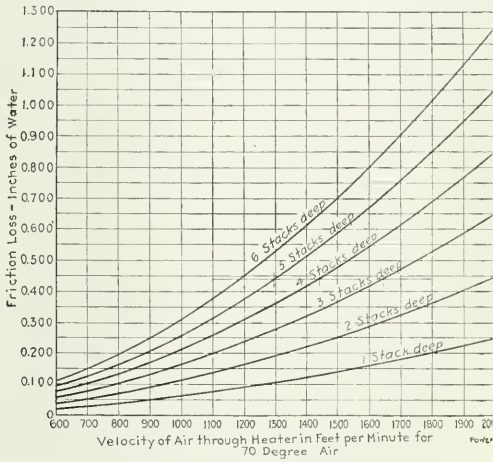


FIG. 2. CHART SHOWING FRICTION LOSSES

thermometers, at *E* the two static-pressure tubes, at *C* the five thermometers measuring the final temperature of the air, and at *B* the manometer registering the velocity pressure. The entire sheet-steel work from the cold-air inlet to the fan was made airtight, since the air was measured on the suction side of the fan.

Tables 1, 2 and 3 show the results of these pipe-coil tests and the equivalent values in Vento heaters. The Vento charts have been used to work out the universal performance of the pipe coils. To illustrate, take the results from Test No. 5 in Table 1 on five 4-row sections

*Abstract of paper read by L. C. Soule before the American Society of Heating and Ventilating Engineers, July 17-19, Buffalo, N. Y.

of pipe coils. Weather clear, barometer 29.95 in., temperature of steam in coils 223 deg.

Refer to the Vento friction chart, Fig. 2. Draw a horizontal line through a friction of 0.44 in. of water, from 223 deg. the 104.4 deg. temperature of air leaving heater leaves 118.6 deg. Draw these horizontal lines of 200.8 deg. and 118.6 deg. temperature on the Vento temperature chart. At the points where the 200.8 deg. line

TABLE 1. COMPARISON OF 1-IN. PIPE COILS WITH 60-IN. REGULAR SECTION VENTO

PIPE COILS, 5 SECTIONS DEEP, 20 PIPES

Heater	Pipe coils	Vento	Pipe coils	Vento	Pipe coils	Vento	Pipe coils	Vento	Pipe coils	Vento	Pipe coils	Vento
Date of test, 1913	Jan. 8		Jan. 8		Jan. 9		Jan. 9		Jan. 9		Jan. 9	
Number of test	3		4		5		6		7		8	
Number of stacks or sections deep	5	4 038	5	4 121	5	4 055	5	4 022	5	4 038	5	4 036
Number of loops or pipes wide	25	14 37	25	14 25	25	14 65	25	14 88	25	14 15	25	14 24
Centers of loops or pipes, in	2 75	5	2 75	5	2 75	5	2 75	5	2 75	5	2 75	5
Friction, in. of water	0 095	0 095	0 31	0 31	0 44	0 44	0 384	0 384	0 25	0 25	0.186	0.186
Velocity of air, ft. per min. at 70 deg	484	670	860	1200	1054	1430	1000	1335	772	1084	662	925
Free area, sq.ft	17 06	12 32	17 06	12 22	17 06	12 57	17.06	12 78	17 06	12 15	17 06	12.21
Temperature entering air, deg. F	23.6	23 6	22.25	22.25	22 2	22 2	24 88	24 88	27 6	27 6	28 4	28.4
Temperature leaving air, deg F	128.2	128.2	110 4	110.4	104 4	104 4	108	108	117 3	117 3	121.4	121.4
Temperature rise, deg. F	104 6	104 6	88.15	88 15	82 2	82.2	83.12	83.12	89 7	89 7	93	93
Total condensation, lb	961 5	961 5	1431	1431	1639	1639	1576	1576	1312	13 12	1169	1169
Condensation per sq.ft. per hr., lb	0 996	1 035	1.482	1 526	1 697	1 725	1 632	1 647	1 359	1 436	1.21	1.27
Per cent. greater velocity with Vento		38 5		39 5		35 7		33 5		40 5		40
Total heating surface, sq.ft.	965.5	928	965.5	938	965 5	950	965.5	957	965 5	914	965 5	920
Per cent. surface required	100	96 1	100	97.1	100	98 4	100	99 1	100	94 7	100	95 3

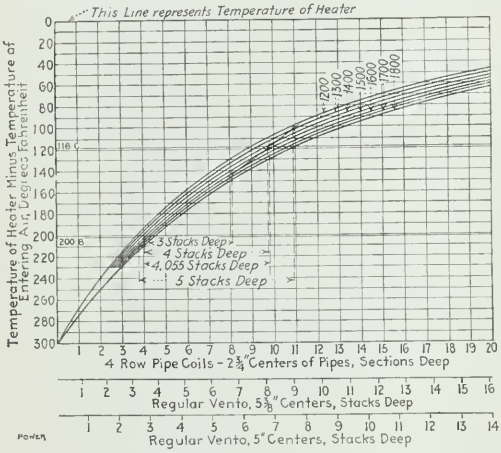


FIG. 3. TEMPERATURE CHART

which is the friction observed in test No. 5 for five sections deep of pipe coils at 1054 ft. per min. velocity. This line intersects three stacks deep of regular Vento sections on 5-in. centers at 1645-ft. velocity, four stacks deep at 1440-ft. velocity and five stacks deep at 1297-ft. velocity.

TABLE 2. COMPARISON OF 1-IN. PIPE COILS WITH 60-IN. REGULAR SECTION VENTO

PIPE COILS, 3 SECTIONS DEEP, 12 PIPES

Heater	Pipe coils	Vento	Pipe coils	Vento	Pipe coils	Vento	Pipe coils	Vento	Pipe coils	Vento
Date of test, 1913	Jan. 16		Jan. 16		Jan. 16		Jan. 16		Jan. 17	
Number of test	12		13		14		15		16	
Number of stacks or sections deep	3	2 395	3	2 417	3	2 439	3	2 593	3	2 483
Number of loops or pipes wide	25	14 56	25	14 47	25	14 98	25	14 12	25	14 59
Centers of loops or pipes, in	2 75	5	2 75	5	2 75	5	2 75	5	27.5	5
Friction, in. of water	0 035	0.095	0 2075	0.2075	0.30	0 30	0 141	0 141	0 241	0 241
Velocity of air, ft. per min. at 70 deg	615	840	917	1260	1130	1560	703	990	987	1345
Free area, sq.ft	17 06	12 5	17 06	12 42	17.06	12 86	17.06	12 12	17 06	12 52
Temperature entering air, deg. F	43 5	43.5	43 3	43 3	45 8	45 8	46 9	46.9	51 8	51 8
Temperature leaving air, deg. F	104 3	104 3	96 3	96 3	94 4	94 4	106 6	106 6	100 8	100 8
Temperature rise, deg. F	60 8	60.8	53	53	48 6	48 6	59 7	59 7	49	49
Total condensation, lb	711	711	922	922	1042	1042	796	796	918	918
Condensation per sq.ft., per hr., lb	1 228	1 274	1 592	1 65	1 8	1 788	1.375	1 358	1.586	1 583
Per cent. greater velocity with Vento		36 6		37 5		32 7		40.9		36 2
Total heating surface, sq.ft	579 3	558	579 3	559	579.3	583	579 3	586	579 3	580
Per cent. surface required	100	96 5	100	96.5	100	100 6	100	101 15	100	100 12

Now refer to the Vento temperature chart, Fig. 3. The temperature of the steam in the heater for test No. 5 is 223 deg. Subtracting from this the 22.2 deg. temperature of entering air leaves 200.8 deg. Subtracting

intersects 1645, 1440 and 1297-ft. velocity, lay off from these points to the right, three deep, four deep and five deep, respectively, of Vento stacks of regular sections on 5-in. centers. From these new points extend vertical lines upward—each to its point of respective velocity. This gives three points which must be connected with a curve as shown. At the point where this curve intersects

TABLE 3. COMPARISON OF 1-IN. PIPE COILS WITH 60-IN. REGULAR SECTION VENTO

PIPE COILS, 1 SECTION DEEP, 4 PIPES

Heater	Pipe coils	Vento	Pipe coils	Vento	Pipe coils	Vento
Date of test, 1913	Jan. 14		Jan. 14		Jan. 14	
No. of test	9		10		11	
No. of stacks or sections deep	1	0 713	1	0.735	1	0.747
No. of loops or pipes wide	25	16 1	25	15 15	25	14 16
Centers of loops or pipes, in	2 75	5	2 75	5	2 75	5
Friction, in. of water	0 114	0.114	0 0325	0.0325	0.075	0 075
Velocity of air, ft. per min. at 70 deg.	1296	1600	637	835	922	1295
Free area, sq.ft	17 06	13 83	17.06	13.0	17.06	12 15
Temperature entering air, deg. F	30.4	30 4	33 6	33 6	36 75	36 75
Temperature leaving air, deg. F	48 3	48 3	56 7	56 7	56.56	56.56
Temperature rise, deg. F	17 9	17 9	23 1	23.1	19 81	19.81
Total condensation, lb	440.5	440.5	279 5	279.5	347	347
Cond. per sq.ft. per hr., lb	2.28	2.394	1.448	1.57	1.796	2 054
Per cent. greater velocity with Vento		23.5		31.0		40.5
Total heating surface, sq.ft	193.1	184	193 1	178	193.1	169
Per cent surface required	100	95.2	100	92	100	87 5

the 118.6-deg. line a velocity of 1430 ft. per min. is obtained. Extend a line downward from this point and another line downward from the point of intersection of 1430-ft. velocity with the 200.8-deg. temperature line and it will be found that the horizontal distance apart of these two vertical lines is equal to 4.055 stacks deep of Vento regular sections on 5-in. centers. This value

for Vento is shown in Table 1 in the column just to the right of pipe-coil test No. 5 with which the Vento is compared.

Test No. 5 velocity through pipe coils of 1054 ft. per

min., multiplied by 17.06 (square feet free area), gives air volume at 70 deg., and this volume divided by 1430 (feet per minute equivalent velocity through Vento) gives a free area of 12.57 sq.ft. This free area is obtained in 14.65 loops wide of 60-in. Vento on 5-in. centers of loops. From these data a total surface of Vento of 950 sq.ft., as compared with 965.5 sq.ft. of pipe coils to do the same work, is obtained.

Three of the tests indicated about 1 per cent. more Vento required than pipe coils, while in the other eleven tests the slight advantage was in favor of Vento.

By plotting all of the pipe-coil test results on the universal temperature chart, Fig. 3, it is found that they agree very closely. From this chart can be read off the performance of these pipe coils under any usual condition of steam pressure, entering air temperature, number of sections deep and velocity of air through the coils.

It was found from the tests, in comparing pipe coils (with pipes on 2¾-in. centers) with Vento heaters, that for the same friction there is 35 per cent. greater velocity through the Vento than through the pipe coils—when using one stack deep of regular Vento on 5⅜-in. centers of loops against each section deep of four-row pipe coils. Similarly, four stacks deep of regular Vento on 5-in. centers equal in friction effect five sections deep of four-row pipe coils when the velocity is 35 per cent. greater through the Vento. The foregoing comparisons in this paragraph apply to a condition of raising a given volume of air through the same range of temperature with the same frictional loss. Under these conditions of equality the amount of heating surface required will be the same with pipe coils as with Vento heaters.

*

Expense of Operating Heating and Ventilating Plants

At the Buffalo meeting of the American Society of Heating and Ventilating Engineers, H. M. Hart read a paper on the above subject, which was based on a report of a committee comprising H. M. Hart, chairman, N. L. Patterson and G. L. Hubbard, to the Illinois chapter. Residence heating, apartment buildings and school buildings were given brief mention, but due to various reasons, there was a wide variation in the figures, so that these data will be omitted.

For office buildings Mr. Hubbard gave the following brief outline of his general practice in estimating the cost of operation of the heating apparatus.

The smaller the plant the greater the cost of heating will be per square foot of radiation, largely on account of the cost of labor. Assuming that the radiation shown on the plans is the correct amount for properly heating the building between the limits of outside and inside temperatures, and that the ventilating equipment is also correctly proportioned, the first thing to determine is the amount of steam that will be used in producing the heat necessary to warm the building. For this it is necessary to estimate the percentage of the total radiation that will be in use continuously and the length of the heating season. For example, in the usual office building in Chicago, with direct radiation in all stories above grade and with ventilating equipment for all stories below grade, he assumed that 65 per cent. of the direct radiation would be in use for the full 24 hours per day for a period of 7 months and 50 per cent. of the fan-coil surface for 10 hours per day for 6 months. With a condensation per square foot of direct radiation of ¼ lb. per hr. and per square foot of fan-coil surface of 1½ lb., the total amount of steam required per year can readily be determined.

Assuming that with the ordinary coal used an evaporation of 6 lb. of water per pound of coal can be obtained under all conditions of load and firing, day in and day out, the amount of coal required during the heating season can be obtained by dividing the steam used by 6. This reduced to tons and multiplied by the cost per ton (say about $2.60 under the usual conditions in Chicago), will give the cost of coal per year. Ash removals should be about 10c. per ton of coal, and the makeup water required should be about 5 per cent. of the total steam per year. The only other item to be considered is the labor, and this must be determined in each case on its own merits. There must, of course, be a man in charge, and as he will have to devote a large portion of his time to work in parts of the building outside of the boiler room, it is probably correct to charge one-third of his salary to the heating plant. In addition, there must be firemen and coal passers enough to handle the fires properly, remove ashes, and see to the normal operation of the boilers, and one or two handy men to do the odd jobs that are always requiring attention.

The foregoing make up all the actual outlay required to produce the steam for heating, but it is customary also to consider depreciation, repairs, etc., which amount to 12 per cent. of the original cost of the plant.

If the pumps required by the plant and the fans are steam-driven and the steam is turned into the heating system no special account need be taken of the amount used, but if they are motor-driven a further sum must be added to the foregoing cost: that for the electric current consumed, whether this is obtained from a plant in the building or from a central-power plant.

In reference to actual practice two different buildings of about the same type and size were taken, one having its own power plant, and the other operating a heating plant only, and the following data given.

In a modern office building equipped with a vacuum system, temperature control, low-pressure boilers and smokeless furnaces, the theoretical fuel consumption is as follows:

The direct radiation is 60,850 sq. ft. The average outside temperature for the seven heating months of 1911 and 1912 was 33.6 deg.; therefore, the theoretical number of hours that radiators would be turned on would be

$$\frac{70 - 33.6}{80} = 0.455$$

and 45½ per cent. of 210 days × 24 hr. would be 2293 hr. Therefore the steam required for heating would be

$$\frac{60{,}850 \times 225 \times 2293}{961} = 32{,}668{,}091 \text{ lb.}$$

To this should be added the loss through piping which is covered with 85 per cent. magnesia. This has been estimated to be 3 per cent. of the total, which would make the total loss by radiation 33,648,133 lb.

For ventilation there are the following units:

One unit delivering 32,420 cu.ft. per min. at an average rise of 26.4 deg. for 20 hr. per day.

One unit delivering 18,400 cu.ft. per min. at an average rise of 28.4 deg. for 20 hr. per day.

One unit delivering 33,860 cu. ft. per min. at an average rise of 51.4 deg. for 10 hr. per day.

One unit delivering 19,500 cu.ft. per min. at an average rise of 76.4 deg. for 10 hr. per day.

The steam required for the above service would be as follows:

$$\frac{\text{Rise} \quad \text{Min} \quad \text{Hr} \quad \text{Days}}{32{,}420 \times 26.4 \times 60 \times 20 \times 180} = 3{,}497{,}717 \text{ Lb. of Steam}$$
$$55 \times 961$$

$$\frac{18{,}400 \times 28.4 \times 60 \times 20 \times 180}{55 \times 961} = 2{,}135{,}521$$

$$\frac{33{,}860 \times 51.4 \times 60 \times 10 \times 180}{55 \times 961} = 3{,}556{,}212$$

$$\frac{19{,}500 \times 76.4 \times 60 \times 10 \times 180}{55 \times 961} = 3{,}044{,}147$$

This makes a total of 12,233,597 lb. of steam for ventilation, which, added to that required for heating, makes a total of 45,881,730 lb. of steam. When burning screenings and evaporating 6 lb. of water per pound of coal this amount of steam would require

$$45{,}881{,}730 \div (6 \times 2000) = 3823 \textit{ tons.}$$

The actual fuel consumption per month was as shown in Table 1.

TABLE 1. ACTUAL FUEL CONSUMPTION IN OFFICE BUILDING.

	Theoretical Tons	Actual Tons	Outside Temperature, Degrees	Average Wind, Miles
October	248	301	53 3	12 8
November	542	573	35 4	16 9
December	547	468	35 0	14 4
January	783	913	11 9	14 2
February	759	656	21 8	14 4
March	640	661	28 8	13 5
April	338	286	48 8	16 5

It will be noticed from this table that, during the months of November and December, the temperature was about the same, but the wind velocity decreased about 15 per cent. and the fuel consumption about 18 per cent. The difference between the months of April and October, of course, is not consistent, but as the engineer had no means of weighing the coal as it was put into the boilers the figures given per month might not be absolutely correct. The cost of operation of this heating plant is given in Table 2.

TABLE 2. COST OF OPERATION OF HEATING PLANT

Coal, 3858 tons at $2.37	$9,143 46
Removing ashes	554 00
Oil, waste and packing	160 00
Repairs	160 00
Labor	4,500 00
Electric current for vacuum and boiler-feed pumps	429 00
Water, approximately	200 00
Interest and depreciation, 10 per cent	2,892 00
Total	$17,978 46

The actual cost of producing steam is

$$\frac{1600 \times \$17{,}978.46}{3858 \times 6 \times 2000} = 38.8c. \textit{ per } 1000 \textit{ lb.}$$

and if the fuel for water heating were added in there would be an additional expense of $2883 for coal and $174 for removing ashes, making the total expense per year $21,035.46. This would bring the cost of steam per 1000 lb. down to

$$\frac{1000 \times \$21{,}035.46}{5074 \times 6 \times 2000} = 34.6c.$$

In another building, almost a duplicate, having its own electric generating plant and hydraulic elevators, the heating load would be about as follows: 68,000 sq. ft. direct radiation, requiring

$$\frac{68{,}000 \times 225 \times 2293}{961} = 36{,}506{,}660 \textit{ lb. of steam}$$

The pipes were covered with molded asbestos and the loss through them may be estimated at 1 per cent., which would bring the load up to 37,966,926 lb.

For heating water the load may be estimated to be about the same as in the previous building, which required 14,600,000 lb. of steam, making a total of 52,566,926 lb. The cost of operation is given in Table 3.

TABLE 3. COST OF OPERATION OF POWER AND HEATING PLANT

6275 tons No. 4 washed nut at $3	$18,825 00
Removing ashes	890 00
Oil, waste and packing	470 00
Water	2,407 00
Lamp renewals	486 00
Labor	9,320 00
Interest and depreciation, 10 per cent.	7,000 00
Total	$39,398.00

To obtain the cost of steam for heating, the deductions given in Table 4 must be made.

TABLE 4. DEDUCTIONS TO BE MADE TO OBTAIN COST OF HEATING

For 644,742 kw.-hr. generated:		
Fuel at 49 lb. steam per kw.-hr	$6,551 00	
Water	249.00	
Lamps	486.00	
Ashes	310 00	
Oil, waste and packing	100.00	
Labor	1,884 00	
Interest and depreciation	3,000.00	
Total	$12,580.00	$12,580.00
For Elevators:		
Coal	$7,712 00	
Water	257 00	
Ashes	364 00	
Oil, waste, etc.	300 00	
Labor	2,700 00	
Interest, etc	1,000 00	$12,333 00
Total		$24,913.00

Then $39,398 — $24,913 = $14,485 would be the additional cost for heating. If this were taken at the same cost rate as the previous building, the cost of heating would be 52,566,926 lb. of steam at 34.4c. per 1000 lb., or $18,083. Therefore, the saving on the cost for heating is

$$\$18{,}083 - \$14{,}485 = \$3598$$

However, this does not represent the actual saving shown by the operation of this plant. The saving would be as follows:

Cost of heating without plant	$18,083 00
Revenue for kw. sold	25,855 00
Revenue for kw. for public lighting	9,928 00
Cost of elevator service	12,333 00
Total	$66,199 00
Less cost of operation	39,398 00
Saving	$26,801.00

New Electric Interurban Railway—Service on the Oakland, Antioch and Eastern Railway was initiated September 3 when a schedule of eight trains daily between Sacramento and San Francisco became effective. On August 30 a two-car train made the run of 91 miles in 3 hr. and 10 min. The J. G. White Companies were represented on this trip by members of the San Francisco office.

The Shepard Pass tunnel, built for this road, and located about 5 miles from Oakland, is nearly two-thirds of a mile long, the longest thus far constructed in this country for an interurban electric railway. The new road is equipped with electric locomotives and steel cars including Pullman and observation cars.

The distribution system from the railway substations is 1200-volt direct current with overhead catenary construction.

The power is supplied by one of the large hydro-electric companies whose lines intersect the railway.

EDITORIALS

Cheaper Power—Reduced Manufacturing Costs

The revised tariff rates shortly to become effective are bound to have considerable effect upon the manufacturing industries of the country. Whether the results are to be beneficial or otherwise depends largely upon the foresight and enterprise of manufacturers in meeting increased competition, etc. In other words, the manufacturer who is to feel the increased competition, more than ever before, must decrease his manufacturing costs, among which one of the main expenses is that for power.

The small manufacturer will undoubtedly be the greatest sufferer and the logical solution, in any case, is increased production to compensate for decreased rate of profit. This is made possible by consequent increased markets. The manufacturer who is brought into competition with foreign products can only successfully meet that competition by reductions in the market price of his own output, which means that he must not only sell cheaper than formerly but he must and will sell more, decreased prices invariably creating increased demands. The manufacturer who is not affected by the introduction of foreign products will find an increased market for his goods, for statistics show that increased importation invariably creates an equal or greater export trade. The manufacturer who in the past has successfully entered the foreign markets will then find his export business rapidly increasing. Increased manufacture must therefore result from reduction in the tariff rates if the American manufacturer is to hold his own.

Increased manufacture will necessitate more factories, increasing the capacity of existing factories or the taking of other means of increasing output as well as reducing manufacturing costs. Building new factories and enlarging old ones will involve the investment of considerable capital, capital for which undertakings will be difficult to obtain until industrial and manufacturing operations recover from the readjustment of conditions that must be expected; i.e., until the industrial and manufacturing situation is once more stable.

Factory output could be increased without additional investment for power if continuous operation were possible. The average factory power house is now in productive operation only about ten hours a day. This is true of the coal-burning plant. Such a plant can be far more economically operated continuously than with the present long and regular periods of productive inactivity.

A power house that is productively operated twenty-four hours each day consumes more coal than one that is inoperative more than half the time, the cost of attendance is greater as is also the expense for oil, waste, supplies, etc., but the plant burden—depreciation, repairs, interest on the investment for land, building and equipment, insurance and taxes—is no greater, or very little greater than when the hours of operation are but ten a day; the result being that the yearly total cost of power in a plant operating twenty-four hours per day and one operating ten hours per day is seventy per cent. (in a plant of one hundred horsepower or so) to fifty per cent. (in a plant of several thousand horsepower capacity) more in the former than in the latter, although nearly two and one-half times as much power is available.

With coal at the average price, that means that the total cost of power per horsepower per hour (brake horsepower at the engine) in the small plant would be reduced from about two and five-eighths cents to about one and seven-eighths cents and in the large plant from about somewhat over one-half cent to not much more than one-third cent. Such economical power production would be even greater than that obtainable by doubling the size of the power house—doubling its ten-hour per day capacity by duplicating the power house. A saving of from one-sixth to three-fourths cent per horsepower, depending upon the size of the plant, would represent a considerable in the cost of manufacturing.

The manufacturer's bill for lighting would be considerably increased by adopting the twenty-four hour day, it is true, but the labor charge need not be appreciably increased by operating three eight-hour shifts (not overtime work) neither would the cost of raw materials be augmented. The latter, in fact, being reduced owing to the better prices obtainable in buying in so much larger quantities than formerly.

Boiler Efficiency

An inexplicable confusion seems to exist as to the basis upon which to calculate boiler efficiency. The 1899 report of the American Society of Mechanical Engineers committee on the "Revision of the Society Code of 1885 Relative to a Standard Method of Conducting Steam Boiler Trials" contains an ambiguity which, if its rare mention is any criterion, has gone undetected for more than ten years by a large majority of the engineering profession. POWER has made editorial mention of it, but, so far as we know, the society has never officially made a correction.

This error appears in rule XXI which states: "Two methods of defining and calculating the efficiency of a boiler are recommended. They are:

"1. *Efficiency of the boiler* =

$$\frac{\text{Heat absorbed per lb. of combustible}}{\text{Calorific value of 1 lb. of combustible}}$$

"2. *Efficiency of the boiler and grate* =

$$\frac{\text{Heat absorbed per lb. of coal}}{\text{Calorific value of 1 lb. of coal}}$$

All of which is just about equivalent to stating that two equals four, for the right side of equation 1 is exactly equal to the right side of equation 2, while the left sides obviously are not equal.

If 80 per cent. of the heat value of the combustible were absorbed the efficiency, according to equation 1, would be

$$\frac{80}{100} \times 100 = 80 \text{ per cent.}$$

nd if the combustible constituted 90 per cent. of the
al. the efficiency according to equation 2 would be

$$\frac{80 \times 90}{100 \times 90} \times 100 = 80 \text{ per cent.}$$

ie same as before.

From a subsequent paragraph of the committee's re-
ort is apparent that what was really meant was

1. *Efficiency of the boiler* =

$$\frac{\text{Heat absorbed per lb. of combustible burned}}{\text{Calorific value of 1 lb. of combustible}}$$

id

2. *Efficiency of the boiler and grate* =

$$\frac{\text{Heat absorbed per lb. of coal fired}}{\text{Calorific value of 1 lb. of coal}}$$

The Power Tests Committee's report presented at the
912 annual meeting contains an improved method of
alculating efficiency.

This report states:

"The efficiency of a boiler is the ratio of the amount
f heat which it absorbs and uses in making steam to
ie amount of heat furnished to it.

"The heat which is furnished to the grate is all the
eat contained in all the coal as fired.

"The heat furnished to the furnace and boiler is that
n the coal which is *burned*. If a part of the good coal
rops through the grate the boiler and furnace should
ot be charged with its heat.

"The Committee on Tests of the American Society of
Iechanical Engineers, therefore, recommends the con-
deration of two efficiencies.

"The efficiency of the grate would equal the first of
iese formulas divided by the second or

$$\frac{\text{Lb. of combustible burned}}{\text{Lb. of combustible fired}}$$

"1. *Efficiency of boiler, furnace and grate* =

$$\frac{\text{Heat absorbed per lb. of coal fired}}{\text{Calorific value of 1 lb. of coal}} = \frac{\text{heat absorbed per lb. of combustible fired}}{\text{calorific value of 1 lb. of combustible}}$$

"2. *Efficiency of boiler and furnace* =

$$\frac{\text{Heat absorbed per lb. of combustible burned}}{\text{Calorific value of 1 lb. of combustible}}$$

This is a great improvement on the older definitions
f and formulas for efficiency and is, perhaps, as compre-
ensive as possible, consistent with simplicity.

One objection that might be raised is that no allowance
made for the moisture content of the coal as fired
hich, with some grades, runs rather high. It is not just
) charge against the furnace and boiler the loss caused
y the heat used to evaporate and superheat the moisture
ontained in the coal. This objection may generally be
ore technical than practical but it is legitimate, never-
ieless.

Another weakness of existing or proposed standards of
oiler efficiency is that no consideration is taken of the
uman factor, which has a very strong influence indeed
pon results obtained, especially with hand-fired equip-
ment. It does not seem feasible, however, to devise a for-
mula to take this human element into exact account.
However, in comparing published figures on efficiency it
is well to bear the possibilities of the human factor care-
fully in mind and refuse to concede that one construc-
tion or type of apparatus is superior to another simply
because a better showing is indicated by the conventional
methods of estimation. An endeavor should first be made
to analyze the report for the purpose of determining just
how great the human element has influenced the results
secured.

⁂

Mr. Williams' Exceptions

In a letter appearing on page 444, Arthur Williams
takes exception to the opinions expressed in our editorial
on the Hall of Records Test. If we were mistaken as to
the purpose of the test we are glad to be set right, but
this all the more strengthens our contentions, for if the
real purpose, as Mr. Williams says, is to determine
whether it is better for the city to continue operating
that particular plant or shut it down and purchase light,
heat and power, then in the latter event the fixed charges
will go on just the same and should be added to the cost
of the purchased product.

Without wishing to dispute Mr. Williams, however, we
are still of the opinion that the outcome of the present
test will have an indirect, if not a direct, bearing upon the
city's policy as regards municipal plants in general.

The main contention of our editorial was that the city
should have conducted its own test and not jointly with
the New York Edison Co., thus not only taking the latter
into its confidence and giving it a voice in determining
the fixed charges, but also giving it daily logs of the test.

We expressed our explicit faith in those actually con-
ducting the test and did not question the scientific stand-
ing of the engineers on the advisory board; nevertheless,
we should expect the New York Edison Co.'s representa-
tives to push their client's interests first, last and at all
times as faithfully as in the past.

As to Mr. Williams' views on fixed charges we have
only to remind him of his remarks at the joint meeting
of the American Society of Mechanical Engineers and
the American Institute of Electrical Engineers on Mar.
10, 1911. We have not seen evidence of any change in
his views since then.

⁂

The Commission of Labor of New Jersey informs us
that as there was no appropriation made with which to
organize the Steam Engineers and Boiler Operators'
License Bureau in the time specified by law, no definite
time limit can be set within which application must be
made to obtain an engineer's or fireman's license without
examination. Nothing can be done by the New Jersey
Department of Labor relative to licensing engineers and
firemen until funds are appropriated and the Bureau
organized. When these have been accomplished mention
will be made in these columns.

We tried to make it plain in our Aug. 19 issue that
the Department of Labor does not give out application
blanks because it has none to give. Nevertheless several
have written to that Department requesting blanks and
mentioning our article.

READERS WITH SOMETHING TO SAY

Safeguarding Sumps in Power Stations

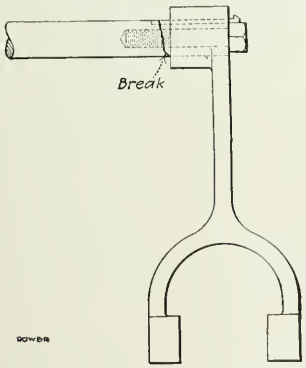
The importance of safeguarding sumps in power stations is shown by an accident that occurred at a lighting plant in a Western city. The pump room, constructed below the level of the ground and lighted by windows only, was drained by an uncovered sump, located at one of the corners of the room, which did not receive much light. The equipment of the pump room included three feed-water heaters, which had been shut down while a thermometer was being installed in the suction of the feed pump. During the progress of the work large quantities of hot water escaped and flooded the floor of the room, as the sump pump was necessarily stopped. The men walked upon bricks which had been placed on the floor. It was necessary to pass near the sump to reach one of the heaters, and the engineer, who had just put the heater in service again, slipped, in some unaccountable way, from the loose bricks and fell into the sump filled with hot water. The accident would not have occurred if the sump had been covered, and it would probably not have happened if the pump room had been lighted by electricity.

ERNEST F. LEARNED.

Watertown, Mass.

Repairs to Broken Rockshaft of Pump

The sketch shows where the rock shaft of a duplex pump was broken. Having to make a quick repair I proceeded as follows: Taking the rock shaft out I tapped a ¾-in. bolt to pass easily through for part of its length as shown. After putting the shaft back in place I tightened up on the bolt drawing the broken parts together, and then drove in the long key, which extends through the rocker-arm and into the rockshaft. The pump has been running this way for more than a year and gives satisfaction.



HOW THE BREAK WAS REPAIRED

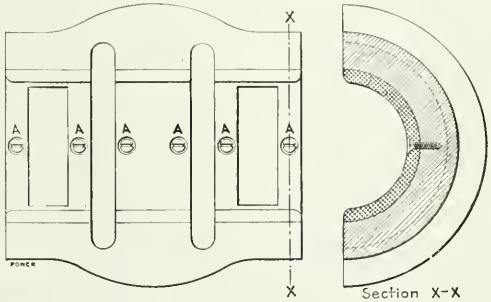
O. R. MASON.

Chicago, Ill.

Fastening Loose Babbitt

The following is a good way to fasten babbitt that has become loose in the bearing or cap:

Drill and countersink a hole through the babbitt and into the metal of the cap or bearing. Make the counterbore large enough so that the head of the screw will be below the babbitt, as shown.



HOW LOOSE BABBITT IS FASTENED TO BEARING

In repairing a large cap, such as shown, put in the screws indicated by A, then when these have been set up hard, drill more holes and distribute the screws according to the area of the babbitt to be held.

J. G. KOPPEL.

Montreal, Can.

Repairing a Pump Piston

Recently I was asked by the foreman machinist of our plant to help repair an old pump for tank service, the pump in question had been discarded by a former engineer as being unfit for use, and was stored away in a damp basement for years. It is a single low-pressure pump, and we found on examining it that outside of rust and dirt, the damage was in the form of a hole worn completely through the follower, evidently caused by allowing the pump to run with the studs and springs loose in the bottom of the piston.

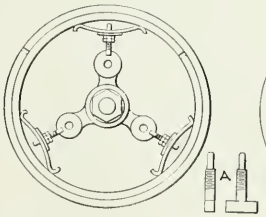


FIG. 1. FOLLOWER PLATE

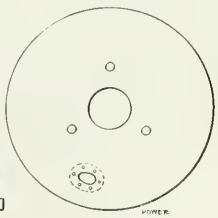


FIG. 2. PUMP PISTON

Fig. 1 shows the type of piston and Fig. 2 shows the follower and the location of the hole at the bottom.

We cut a piece of $\frac{3}{16}$-in. flat iron to the shape shown

by the dotted lines, Fig. 2, and riveted it to the outside of the follower. It was made tight by calking. To prevent the studs and springs from falling down, we made new studs like A, Fig. 1, with tee instead of square heads; the width of these heads was made a close fit in the slots in the spider, and the heads were made as long as possible without interfering with the follower bearing against the spider. This pump now gives satisfaction and the foreman and I are thinking that we have saved our company the price of a new pump.

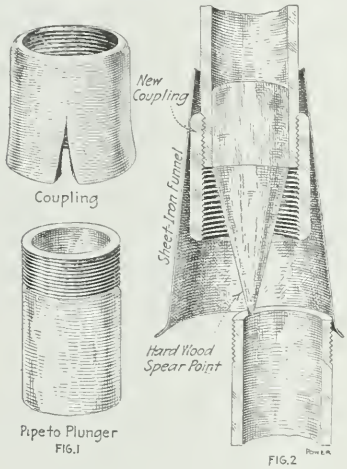
L. JOHNSON.

Exeter, N. H.

Removing Plunger from Deep Well

Readers may be interested in a method made use of in recovering the plunger and foot valve from a deep nonflowing artesian well.

During the process of overhauling and making general repairs to a deep-well pump of the vertical type used in this nonflowing artesian well, it became necessary to remove the rod, plunger and foot valve. After removing the large bolts at the base of the pump and swinging it from its position over the well, the pump rod, which was of extra heavy iron pipe, the lengths of which were connected by iron-pipe couplings, was drawn out through the 4-in. casing of the well.



PARTS OF CASING FINDER

Upon removing the rod it was found that it had parted at a coupling near the plunger and that the plunger was still in the working barrel at the bottom of the well. Examination showed the coupling at the end of the rod to be much worn on one part from rubbing on the well casing. The extra strain on it, caused by the attempt to draw the plunger through the unused part of the working barrel had probably caused the coupling to split open at one end, see Fig. 1, and come up with the rod, leaving the plunger behind.

Instead of fishing for the remaining part of the rod with grappling hooks, as is commonly done in cases of this kind, the pump rod was again lowered into the well after being fitted with a new coupling, the threads of which had been made so as to insure an easy fit to the threads of the old pipe. A sheet-iron funnel and a hard-wood spear point were used to help guide the new coupling to its position for making up with the old pipe, as shown in Fig. 2.

The funnel at its open end was made only slightly less in diameter than the casing of the well; so that if the lower end of the pump rod were against the casing of the well at any position, the funnel when passing over it would cause it to be thrown toward the center, where the hard-wood spear point, being somewhat shorter than the funnel, would engage in the pipe and because of its tapering shape would throw the rod into the right position for making up with the coupling of the upper portion of the rod.

The device proved very successful and at the first attempt the threads of the coupling engaged those of the lower part of the rod and after a few turns with a wrench, the rod, with the foot valve and plunger, was drawn from the well without further trouble.

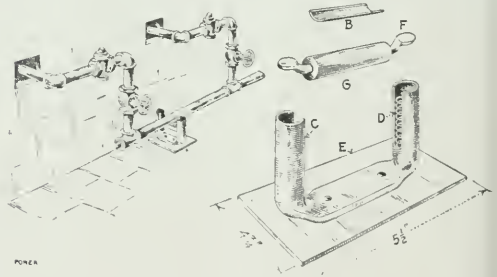
H. E. BROOKMAN.

Trenton, N. J.

Expansion Support for Blowoff Line

In the plant where I am employed the boiler settings were all rebuilt. The boilers, six in number, are 150-hp. horizontal return tubular, each provided with a 3-in. blowoff pipe. The blowoff line is exposed, running along the floor and raised about 3½ in., see Fig. 1, to permit the boilers to settle, while drying out. This line could not be braced solid on account of the boilers settling and breaking the connection, so the following expansion brace was made.

A piece of ¾-in. pipe, 15 in. long, was punch-marked and ⅜-in. holes drilled through 3½ in. from each end, so that a piece shaped as *B* could be taken out of each end of the pipe as at *C* and *D*.



SUPPORT FOR BLOWOFF PIPES

The pipe was then heated to the proper temperature and flattened out at *E* in the center and the ends bent at right angles as shown. The pipe was next mounted on a base of iron ⅛x4½x5½ in. and two springs of the proper tension 4 in. long and 1 1/16 in. in diameter inserted in the ends of the upright pieces *C* and *D*. The crossbar *F* is made from ½-in. iron with the ends flattened and rounded to 11/16 in.; it is provided with a roller *G*. ⅝x2½ in. long. This bar rests on a spring and supports the main blowoff line.

C. R. VAN KEUREN.

Famosa, Calif.

QUESTIONS BEFORE THE HOUSE

Connecting Waterwheel and Engine

Under "Inquiries of General Interest" in Aug. 19 issue, I noted one in regard to connecting waterwheels to engines. From the experience of our company with the same sort of equipment, I would suggest that it is very inadvisable to connect waterwheels and steam engines together without a governor on the waterwheels as well as on the engine to prevent racing should the load become less than the capacity of the waterwheel. If the two prime movers are necessary at all times, the governors on the waterwheels need be only of such type as to prevent them reaching a dangerous speed. It seems preferable, if the two prime movers are driving electric generators, to connect them electrically if generating alternating current, rather than by a clutch of any form. Clutches are often unavoidable, where the combined power is to be delivered to a single shaft, but they are often troublesome to such an extent as to drive one to despair.

J. E. Harlow.

Dixon, Ill.

The Failure of a Hot-Water Tank

From the description of the defects related by R. Cederblom, page 139, of the July 22 issue, as occurring on the head of a hot-water tank that came under his observation, I should say that he may be practically certain that the initial cause of the trouble was a breathing action, similar in character to that which produces the so called lap crack in boilers.

Any tendency toward pitting or corrosion along definite lines is almost invariably produced by some disturbance of the fibres of the metal along such lines, the disturbance preventing the formation of scale which would protect the metal from the corrosive action of the contents. When disturbance occurs, and fresh unprotected surfaces are constantly presented for corrosive action, the rate of action is unbelievably fast. Water that under other circumstances has no corrosive effect, will under such conditions cut a groove in a remarkably short time.

In boiler practice, grooving near the turn of the flange on flat heads of domes, if not braced, is very common. When the two-flue boiler was in general use, grooving at the girth seams was a common occurrence. These boilers were long and of small diameter, and their weight was usually carried at the front and rear ends. With a boiler of 42-in. diameter and 36 ft. long (which was an average size) there was considerable movement endwise, due to expansion, and the sag produced by the weight of boiler and contents, and the effect of this movement was concentrated at the girth seams, and produced girthwise grooves around the bottom half of the boilers on the inner surfaces of the sheets, near the edge of the girth-seam lap. The bumped heads of domes and drums are not immune to such action, because the standard bump does not produce a head that tends to retain its shape with the application of internal pressure, and in many cases the movement is sufficient to produce rapid growing.

Bracing a flat head by means of angle iron, as shown by Mr. Cederblom, is not satisfactory, unless the angles are carried right up to the turn of the flange, or better still, have the ends of the angle iron fitted to the sweep of the flange, but even under such circumstances this style of bracing is not suitable for high-pressure work.

J. E. Terman.

Hartford, Conn.

Factory Fire Chiefship

Referring to the editorial on the above subject on page 238 of the Aug. 12 issue, you undoubtedly know, if these factories would put in automatic sprinklers, the fire chief would be wholly supernumerary. Incidentally, there would be no loss of life, no panic, no fire loss to speak of, under any circumstances; and the reduction of insurance premiums would pay for the sprinklers within four or five years.

When commenting on such a disaster as that at Binghamton, do you not think it worth while to consider a few of the points above mentioned?

Sidney S. Koon.

Boston, Mass.

[While sprinkler systems are highly commendable and do lower insurance rates, they do not make unnecessary the presence of the factory fire chief. We did not mention these things in our editorial, for as stated in an editorial remark following a discussion letter commenting on our editorial on this same subject in the Dec. 24, 1912, issue, our field is not fire prevention. Our aim is to stop the practice of adding to the responsibilities of the engineer by appointing him chief of the factory fire department.—Editor.]

16 Lb. per Hp.-Hr., Noncondensing

I have read with interest the report in the July 15 number, page 105, of the test by F. W. Dean, of Boston, on an Erie City Iron Works' Lentz simple noncondensing engine. The results as claimed in the report are such as to cause some skepticism on the part of the reader.

There are a number of statements in the report as published, as well as a number of conditions which are not stated, that require further explanation before one can give full credence to the published results. I notice the statement: "Steam was so perfectly condensed that only a trifling quantity of vapor escaped, so small that it would not affect the result by a measurable quantity." If, as here admitted, the condensed steam left the condenser at so high a temperature as to steam in the open air, does this not vitiate the results?

It is known that the power of the atmosphere to absorb moisture is great; and if the water flowed from the condenser at a steaming temperature (which is admitted) the steam consumption of the engine would be some greater than that apparently shown.

It is common, in tests of boiler efficiency, to raise decided objection to the weighing in open tanks of feed water at steaming temperature; and there is no reason why the same argument should not prevail in an engine test.

I notice also the statement: "The reducing motion was practically correct." If the reducing motion is the same as usually employed on this engine, it may be practically correct, but not exactly correct; so is not this also an admission of possible error in the indicator diagrams by reason of a faulty reducing motion?

The article further states: "Current was absorbed by a water rheostat." I should like to know more regarding the kind of rheostat employed, and have further information regarding the steadiness of the load carried.

It is a difficult matter to carry an exactly steady load with a water rheostat, as usually constructed; and if, as is stated, "the indicator diagrams were taken every ten minutes, with a Crosby inside-spring indicator," it would be expected that the load was varying considerably during the ten-minute intervals; and it would be correspondingly quite impossible to determine whether the average of the indicator diagrams taken at so wide intervals equaled the average load as actually carried.

If the indicator diagrams were taken at moments when the water rheostat gave an excessive load, that would in part account, in addition to the other points above raised, for the apparently low steam consumption as claimed.

Nothing is said about the calibration of indicator springs; and here again is another uncertainty.

My further reason for questioning the accuracy of the results is that figures hitherto published, showing the steam consumption of this type and make of engine, do not show so remarkable results. I refer to POWER, June 3, where a 12x18-in. Erie City Lentz engine showed, with 149.6 lb. initial pressure, and 5 lb. back pressure, 25 lb. of steam per i.hp.-hr.; or a claimed result, by calculation for 150 lb. pressure and zero back pressure, of 22.25 lb. of dry steam per i.hp.-hr.

In POWER of Dec. 31, 1912, there is a report of a test on an Erie City Lentz 15x21-in. engine, at 145 lb. pressure, 2 lb. back pressure, 47 deg. F. superheat, in which the steam consumption per indicated horsepower-hour was shown to be 19.2 lb.

In both of these tests, as hitherto published, the engines were of a stroke which is long with respect to the bore, and in consequence a low clearance volume would be expected in both engines.

On the other hand, the engine recently tested is 19x21 in., and it is manifest that such a size of cylinder cannot have as small a percentage of clearance volume as in the case of the other two engines reported upon. Moreover, in this last test, the steam pressure carried is from 12 to 17 lb. lower than in the other tests.

The best result hitherto accomplished, as far as I have been able to learn, by test of a four-valve poppet-valve noncondensing engine is published in *Zeit. d. V. D. I.*, August, 1905, page 1310, where a 16.3x39.4-in. simple engine, with 145 lb. initial gage pressure, atmospheric exhaust, 254.3 deg. F. superheat, showed 16.10 lb. of steam per indicated horsepower-hour. Here is a poppet-valve engine with a stroke more than double the bore and, in consequence, with small clearance, and with superheat of over two and one-half times the amount of superheat carried on the Erie City Lentz test; yet this German engine shows the same steam consumption as claimed for this Erie City Lentz engine. Does it not appear probable, in the light of the above mentioned points, that the true results for the engine in question would be nearer 18 lb. of steam per indicated horsepower-hour?

ASA P. HYDE.

Binghamton, N. Y.

Hall of Records Test

Some misunderstanding is indicated in the editorial appearing in your issue of Aug. 26, upon the test now being conducted at the Hall of Records. The object of this test is to determine which is the more efficient method of obtaining light, heat and power for this building—by a private plant or from outside sources. The test is three cornered, in that it is being jointly conducted under the auspices of the administration of the Borough of Manhattan, the Bureau of Municipal Research and the New York Edison Co. Those in charge are of such unquestioned scientific standing and repute that the results, whatever they may be, will undoubtedly be accepted as final, so far as issues exist within the limits of the test.

In a part of your article, statement is made that "judging from past experiences, the representatives of the Edison Co. will undoubtedly try very hard to burden the plant with all sorts of fictitious fixed charges and it behooves the other members of the board to take a determined stand against such attempts." Would it be practicable to indicate an instance where this company has endeavored to burden any plant with fictitious fixed charges?

That such a test as this could be arranged with the officials of the city is gratifying evidence of the desire of those charged with the administration of the city's practical affairs to render the highest grade of public service. In this matter the truth only is sought, and whatever the result it cannot be harmful to the city, for if it be in favor of the continued operation of the plant assurance will then be had that no cheaper method of obtaining light, heat and power exists; if it be in favor of private electrical and steam service from outside sources, again the city will be benefited in securing the elimination of waste and needless expense, in that corresponding service can be obtained with less expenditure of money.

It should not be inferred that at this or any other time any criticism has existed concerning the conduct of this plant. Probably no private plant has ever been operated with greater watchfulness and efficiency, especially during the past two or three years under the present administration. It is a test of the best that can be done with a "private" plant, in comparison with the usual and ordinary commercial service of a corresponding nature.

ARTHUR WILLIAMS,
General Inspector,
N. Y. Edison Co.

New York City.

ENGINEERS' STUDY COURSE

Boiler Efficiency

Solution of Practice Problem

At the plant in question the atmospheric pressure is 13 lb. per sq.in. and according to the steam table, the total heat of dry saturated steam at that pressure is 1148 B.t.u. per lb. and its temperature is 205.9 deg. Another reference to the steam table shows that the absolute pressure of steam having a temperature of 377.6 deg. is 190 lb. per sq.in., and the heat of the liquid of such steam is 350.4 B.t.u. per lb. while the latent heat is 846.9.

Then, substituting in the formula given last week for calculating the quality of steam we have

$$Q = \frac{(1148 - 350.4) + 0.46\ (286 - 205.9)}{846.9} =$$

$$\frac{797.6 + (0.46 \times 80.1)}{846.9} = \frac{797.6 + 36.8}{846.9} = 0.9852$$

or 98.52 per cent. as the quality of steam

Boiler Efficiency

Usually the sole purpose of a steam boiler is to generate steam. To do this, heat is required and this is obtained by burning fuel in a furnace connected with the boiler. In reality, there are two distinct steps in the process of steam generation and two parts in the apparatus employed. First, heat must be generated and for this the furnace and grate when solid fuel is used are required. Second, the heat generated must be transferred to water so as to convert it into steam and for this the boiler proper is provided. The degree of perfection or the efficiency with which each part does its work depends partly upon its design and partly upon the skill and care employed by the operators.

The efficiency of the boiler alone is the ratio of the heat absorbed by the water within to the heat supplied to the heating surface. To illustrate, if by calculation based upon the pounds of water evaporated and the pounds of fuel actually burned, it were found that for every 1000 B.t.u. actually liberated by the combustion of the fuel, 740 is transferred to or absorbed by the water in the boiler to make steam, while the balance was lost in various ways, the efficiency of the boiler would be as 740 is to 1000, or

$$\frac{740}{1000} \times 100 = 74\ \textit{per cent.}$$

On the other hand, the efficiency of the boiler and grate, taken as a whole, is the ratio of the heat absorbed by the water to the total available heat supplied to the furnace, the latter item being based on the number of pounds of fuel fired and the heat value of the fuel when fired.

The difference between these two methods of calculating efficiency is that in the first case the boiler is not charged with the loss due to unburned fuel dropping through the grate, which is proper as only the grate and not the boiler ifself is responsible for loss in this direction. Hence, this loss is taken into consideration only when the boiler and grate are all considered as one unit.

It is customary to state both efficiencies when making a report of a test but the one of greater interest in everyday plant operation is the efficiency of boiler and grate. In brief form the two efficiencies are:

$$\textit{Efficiency of boiler} = \frac{\textit{heat absorbed per lb. fuel burned}}{\textit{heat value of 1 lb. fuel}}$$

$$\textit{Efficiency of boiler and grate} = \frac{\textit{heat absorbed per lb. fuel fired}}{\textit{heat value of 1 lb. fuel}}$$

A boiler test may be elaborate or simple, depending upon the object in view. With the elaborate test every factor possible is taken into consideration and the greatest possible accuracy is secured. With the simple test less effort is made and fewer factors are considered. The simplest test takes into consideration only the weight of the water apparently evaporated and the weight of the fuel supplied to the furnace. In between come the happy mediums which are elaborate enough to insure reasonable accuracy and simple enough to avoid expensive complications and justifiably dispensable effort. Such a one will be herein outlined. It may be further simplified on the judgment of the man who is conducting the test. All the principles involved and all the calculations entering into the making and reporting of this test have been taken up in detail in previous lectures and it only remains for the writer to show how they all are brought into application when conducting a test.

Test Apparatus Required

The following apparatus is required for properly making a test as here outlined:

1. Equipment for measuring or weighing water evaporated.
2. Equipment for measuring or weighing fuel.
3. Two draft gages; one at damper, one at furnace.
4. Four thermometers: one for feed water, one for steam calorimeter, one for flue gases and one for air.
5. One complete flue-gas analyzing set.
6. One steam calorimeter.
7. One outfit for making proximate fuel analyses.

Weighing Feed Water

As probably has been assumed from foregoing paragraphs, one of the main factors to be determined is the weight of water evaporated or steam generated during the test. This factor can be ascertained in two ways. First, the water can be measured or weighed before it is fed to the boiler or, second, the steam given off by the boiler can be collected, condensed and measured or weighed.

The latter method is, perhaps, the more reliable because only water that has been condensed from steam will be weighed while with the first method all the water pumped into the boiler may not be evaporated during the

est. If the blowoff should be leaky some of the water night escape in that direction without being converted into steam; also the water level in the boiler might not be the same in the end as in the beginning of the test, thus causing error in the amount of work credited to the boiler.

It is seldom, if ever, possible to condense and weigh the steam from a boiler being tested because usually it would be very inconvenient and expensive to install a special condensing equipment. Besides, this method would require taking the boiler out of service which sometimes cannot be done. However, with reasonable care the other method gives practically as reliable results.

Numerous methods of measuring or weighing the feed water can be devised and the one best to employ for any given test depends upon local conditions, size of the boiler, etc. Ordinarily, two tanks will suffice, one for measuring or weighing the water as it is received from the heater and one, to which the feed-pump suction is attached, to act as a receiving or storage tank. The tanks and the feed pump should be located as close as possible to the boiler to be tested so as to avoid radiation losses. The most convenient arrangement is to have the measuring or weighing tank placed upon a platform directly over the receiving tank so that the discharge to the latter will be as direct and rapid as possible. Preferably, the upper tank should rest on a set of scales so that each tankful may be actually weighed. If this is not convenient the tank may be provided with a suitable overflow and filled to overflowing each time, the capacity having first been accurately determined by either actually measuring or weighing the contents.

If possible, the thermometer for measuring the temperature of the feed water should be inserted in the feed pipe close to the boiler by means of a mercury thermometer well. If this cannot be done, the thermometer should be hung in the suction tank.

For measuring the fuel, if it is oil, a meter is usually employed, although a tank arrangement similar to that for the feed water could be used, suitable precautions being provided, of course, against fire. If the fuel is solid, two or more ordinary wheelbarows of suitable capacity will be required together with a set of ordinary platform scales. If the scales are of the portable variety, wooden runs for rolling the barrows up onto the platform and down off of it again will be found convenient.

The two draft gages, specified as item 3, while not absolutely essential, will be found instructive and helpful in analyzing results. One should be connected with the furnace and the other, with the uptake on the boiler side of the damper. Any type of gage will suffice, although the more accurate it is and the closer it can be read, the better.

The only absolutely necessary thermometer specified in item 4, is that for measuring the feed-water temperature. The others may be dispensed with if small economy is any object. In this case, the steam calorimeter would also have to be dispensed with and the quality of the steam, and the temperature of air and flue gases, all of which factors influence the results, would have to be guessed at.

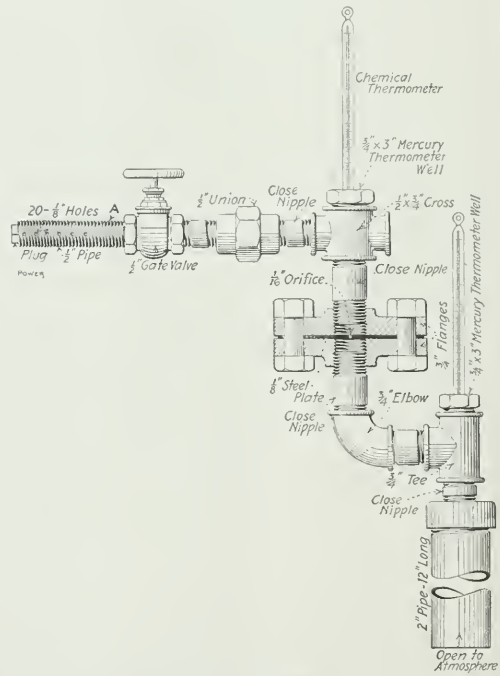
The cost of the thermometer for the feed water should not be very great as a range up to 212 deg. will do, because the feed water must be handled at atmospheric pressure and, hence, a temperature higher than 212 would be impossible. Thermometers for measuring the ordinary atmospheric temperatures are very cheap. Indeed, they are often given away as advertisements or souvenirs, consequently, there is little excuse for not using one during a test. It should be hung in such a location that it will indicate with fair reliability the average temperature of the air entering the boiler room.

The specifications and directions for using the thermometers for the flue gases and the steam calorimeter were given fully in previous lessons (July 29 and Sept. 16, issues) and need not be repeated here.

The function and value of the proximate coal-analysis outfit, flue-gas analysis apparatus and the steam calorimeter have also been fully discussed in previous lessons (May 20, June 17 and Sept. 16 issues). If a test is an important one it is advisable to send a carefully collected sample (see lesson in May 20 issue) of the fuel to a commercial chemical laboratory for proximate analysis and heat-value test in order to have a check on your own work.

Object of Test

Boiler tests may be made for almost any purpose: To test the performance of a new installation; ascertain the efficiency of the boiler under operating conditions; determine the maximum capacity that can be developed; find the value of a certain grade of fuel or to compare one grade with another; discover the effect of change in furnace design, type of grate or stoker, arrangement of baffles, etc.



Construction of Home-Made Steam Calorimeter

When tests for comparing one set of conditions or one

kind of fuel with another are made, especial care should be employed to keep the operating conditions as uniform as possible so that a perfectly fair comparison may be made. For instance, suppose a new furnace is being tried out. First, a test or series of tests with the old furnace would probably be run to discover the existing economy and then a test or series with the new equipment would be conducted to discover what improvement, if any, had been secured. Now, it would obviously be unfair to overhaul the boiler between the first and second tests or series, cleaning it thoroughly both outside and in and carefully pointing up all cracks in the setting, etc., and then credit to the new furnace the improvement in efficiency thus brought about. In the same way, it would be unfair to employ a higher grade of skill in operation during one set of tests than during the other, unless, of course, the men of the greater skill were to operate the plant continuously in the future.

On the other hand, if the boiler were to be tested to find out just what degree of efficiency was attainable, it would be poor judgment not to take every precaution possible in the way of tuning up just before the test.

Thus, the object or purpose of a test should be kept carefully in mind and the method suitably adjusted to attain the desired object as fairly and satisfactorily as possible.

[NOTE—The figure accompanying this lesson and illustrating the construction of a home-made steam calorimeter should have appeared with last week's lesson. Through an oversight in making up it was omitted.—EDITOR.]

Transporting Coal through Pipe Lines

The method of transporting coal by water pressure through a pipe has been suggested by E. G. Bell, engineer for the Hammersmith Electricity Works of London. By this method from 30 to 60 tons of coal per hour can, it is claimed, be forced through an 8-in. pipe leading from the Thames and under Chancellors' Road to the yard of the power plant on Fulham Palace Road, a distance of 600 yards.

If the scheme is adopted, a large mixing tank will be erected beside the wharf. The coal will be lifted from the barge by a mechanical grab, and after passing through an automatic weighing machine, it will be filtered into the mixing tank, which will contain approximately 15 per cent. of coal and 85 per cent. of water. A powerful electrically driven pump will then force the mixture of coal and water at high velocity through the transmission tube to a reception tank at the works.

The coal will sink to the bottom of this tank and another pump will drive the water through a return pipe to the mixing tank. Another grab will lift the coal out of the reception tank into the storage yard.

Although the initial cost of such a plant might be high, it is believed that it would eventually be a paying investment, since the present cost of transportation is approximately 14c. per ton, or somewhat over $3500 for the 25,000 tons which are used annually.—*Coal Age.*

The Indiana Coal Production in 1912, according to E. W. Parker of the United States Geological Survey, was 15,285,718 short tons. The increase over 1911 was 7.7 per cent. in quantity and 14 per cent. in value.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Sure we were there! And you? If all the good things that were said and done were bunched, the answer would be: The Springfield N. A. S. E. convention was the best ever! And this is no idle boast, either. Everybody said so.

We met hosts of old friends and fraternized with lashings of new ones, to each of whom we would like to say something pleasant. But how can we in just one column of "Power"? The report of the convention is on page 450.

The only partiality we show is forced on us by the great work done by Walter Damon, the man who put the spring in Springfield. Indefatigable in his labors as chairman of the local committee to make the convention surpass all others, he worked day and night smoothing out the rough places and setting the machinery in motion. And he got away with it, always with a cheery word and an eye for the comfort of all.

Just one more word: We are tickled to the quick over the warm reception given our convention daily, the "Power Pup," and we thank you, one and all

The blacksnake whip has been abolished in an Indiana coal mine as a persuader of the mine mule. Looks like the only method left was to cuss 'em out. The mule that will locomote without either of these old-fashioned but heretofore effective persuasions must verily be of a new breed.

A centenarian gives advice to those of us who would hope to live 100 years. Among his rules are: "Don't worry. Keep out of jail." With some people, getting into jail has brought most of their worries to an end, but we can't all live in a big village like New York.

Don't get peeved when you read the article on the Lemp Brewing Co.'s plant in this issue. Nothing is said of its product. It's a good description of an efficient, well kept plant. Any good brewers' journal will give you the other details.

We agree with a former President that a pension list is a roll of honor. The Pennsylvania System has 3972 pensioners on its list. The road is proud of them, and the men are equally proud of their long-service records and the recognition thus given. How many years have you been with your company? How long will it be before you are entitled to a pension? There is a good, big thought in these two inquiries.

"How did I get to the top of the heap?" said a big executive.

"Why, I answered the questions before they were asked." You get that, don't you?

"If you want to continue wearing your straw hat," says a contemporary, "and anyone tries to haul it down, spot him on the snoot!"

This is not a specimen of that editorial dignity with which we operate our editorial columns, but, taken unawares, we might say just this thing ourselves.

Thomas A. Edison's recent indisposition is ascribed to his taking a vacation, thus breaking up his long years of intense application and burning the midnight oil. Now you know why you are so healthy in your seven-day-a-week job.

Secretary of State Bryan in greeting the members of the International Congress of Refrigeration informed them that the principle of cold storage might well be applied to diplomatic relations.

"Diplomacy is the art of keeping cool," said Secretary Bryan. "While we do not desire to keep our foreign relations in cold storage, we want to refrigerate our disputes with other nations." He also said that such treaties as the peace agreements he proposed to the nations of the world on behalf of President Wilson will serve to keep the temper of nations cool, just as refrigeration keeps foodstuffs cool.

Throttling Calorimeters

SYNOPSIS—The principle of the throttling calorimeter explained and illustrated. An example is given whereby the percentage of moisture in steam as determined by the calorimeter is worked out.

Percentage of moisture in steam below 3 per cent. can be determined by the throttling calorimeter, an apparatus in which steam is allowed to expand from pressures above atmosphere through a small opening and, by reading the pressures and temperature of the steam before and after expansion, the percentage of moisture can be determined.

The principle of the throttling calorimeter is best explained by reference to Fig. 1. Steam under pressure flows through the pipe at *A* and passes through the orifice where it expands to atmospheric pressure, or nearly so, in the open pipe *C*.

Assuming that the contents at *A* is dry-saturated steam containing a certain number of heat units per pound, then dry-saturated steam at *C* would not contain the same number of heat units as when under pressure at *A*, and it

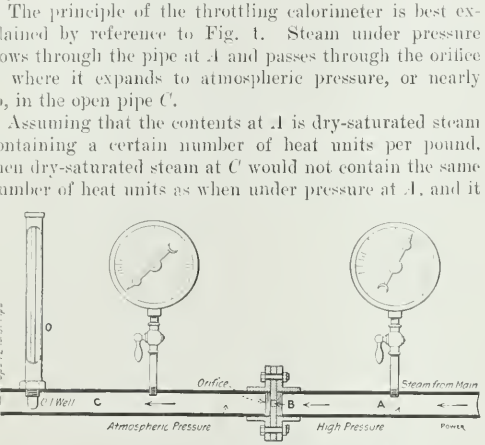


FIG. 1. DIAGRAMMATIC VIEW OF CALORIMETERS

follows that some of the heat in the steam at *A* will go toward superheating the steam at *C* at the lower pressure. If any moisture is present when the steam is at *A*, some of the heat in the steam will go toward evaporating this moisture when the steam expands at the orifice. It follows that the temperature of the steam will then not be as high as when there was no moisture.

For example, suppose steam at *A* is at 90 lb. absolute pressure, dry saturated, then by referring to a steam table can be found that the total heat (above 32 deg. F.) 1 lb. of steam will be 1184.4 B.t.u. At atmospheric pressure 1 lb. of steam when dry saturated contains a total heat (above 32 deg. F.) of 1150.4 B.t.u. From this is seen that

$$1184.4 - 1150.4 = 34 \text{ B.t.u.}$$

available and that this must go toward superheating steam at atmospheric pressure. Then 34 B.t.u. will

$$34 \div 0.48 = 71 \text{ deg. of superheat}$$

specific heat of superheated steam at atmospheric pressure being say 0.48. As the temperature of dry-saturated steam at atmospheric pressure is 212 deg. F., there would be a thermometer reading at zero of

$$212 + 71 = 283 \text{ deg. F.}$$

Now if the steam at *A*, while still at 90 lb. absolute pressure, had contained a percentage of moisture, some of the available 34 B.t.u. would have gone to evaporate this moisture and only a part would have superheated the steam, so that the thermometer reading would have been less than 283 deg. F. This thermometer reading serves to determine the percentage of moisture present in the steam at *A*. From this it can be seen that if enough moisture is present at *A* to take up all the 34 B.t.u. to evaporate it so that there will be no superheating—that the thermometer will not register over 212 deg. F.—the limit of the usefulness of the throttling calorimeter is arrived at and, for this reason, it cannot be used for moisture of over 3 per cent.

The formula for the percentage of moisture in steam as determined by the throttling calorimeter is

$$W = 100 \times \frac{H - h - K(T - t)}{L}$$

where

W = Percentage of moisture in the steam at A;
H = Total heat in the steam at the high pressure;
h = Total heat due to pressure at C, which is 1150.3 B.t.u. at atmospheric pressure;
K = Specific heat of superheated steam = 0.48;
T = Temperature of the throttled or superheated steam at C;
t = Temperature due to pressure at C, which is 212 deg. F. at atmospheric pressure.

H, L, H and t can be found in the steam table when the pressures are known.

To illustrate, assume that the pressure at A is 75 lb., that at C is at atmospheric pressure, or 14.7 lb., and that the thermometer reads 232 deg. F. Then by turning to the steam table

$H = 1181.1$;
$L = 893.9$;
$h = 1150.3$;
$t = 212$ deg. F.

It is assumed that

$T = 232$ deg.;
$K = 0.48$.

Then substituting in the formula

$$W = 100 \times \frac{(1181.1 - 1150.3) - 0.48\ (232 - 212)}{893.9}$$

$$W = 100 \times \frac{30.2 - 0.48 \times 20}{893.9} = 100 \times \frac{30.2 - 9.6}{893.9}$$

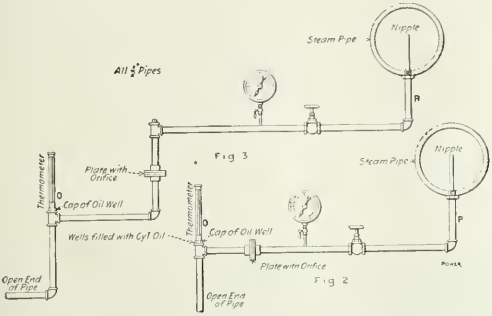
$$= 100 \times \frac{20.2}{893.9} = 100 \times 0.022 = 2.6$$

or 2.26 per cent. of moisture in the steam at *A*.

How to Make a Calorimeter

An engineer without a calorimeter and not caring to buy one, can make it. Figs. 2 and 3 show two forms of calorimeters. Use ½-in. pipe throughout and cut it to any reasonable and convenient length. The nipples inserted into the steam pipe or union are open only at their upper ends and should reach to the center of the steam pipe, but if preferred, the sides can be perforated with a few holes not over ⅛ in. in diameter. The nipple is essential because if it were only screwed and did not protrude into the central part of the pipe, the condensation would pass into the calorimeter and give erroneous

results. The gages are not essential, as the pressure in the pipe is probably known from gages elsewhere in the line, but it is advisable to have one on or near the calorimeter for convenience and accuracy. The thermometer is necessary, but it must be accurate, with a range from 200 to 350 deg. F. The plate held in the flange union should be about $\frac{1}{8}$ to $\frac{1}{4}$ in. thick, and have a hole in the center $\frac{1}{16}$ to $\frac{1}{8}$ in. in diameter. The entire length of the apparatus should be covered to prevent condensation as far as possible. Only the valve wheel should be free and a hole left in the covering for the thermometer. The oil well at O should have a cup whose outside diameter is not large enough to allow steam to pass around it freely in escaping to the atmosphere.



FIGS. 2 AND 3. VERTICALLY AND HORIZONTALLY CONNECTED CALORIMETERS

When taking readings the valve should be opened full and steam allowed to flow for a few moments to heat the apparatus. When the thermometer shows a constant temperature the reading should be taken. This reading represents T in the formula. The pressure on the high side should also be observed from which the values H and L are found in the steam tables. As the low pressure is assumed to be atmospheric, $h = 1150.4$ and $t = 212$ deg. F.

INSTRUMENT ERROR

In the preceding example it was assumed that the temperature of the steam on the low-pressure side would be 212 deg. F. if the steam were dry saturated, and if the steam on the high-pressure side were dry saturated at 90 lb. pressure the temperature of the superheated steam in the low-pressure side, as registered by the thermometer, would be 283 deg. F. This is known as the "normal reading." But the thermometer will not register 283 deg. even if the above conditions prevailed as the reading will be slightly lower.

One reason is that a certain amount of heat will radiate through the calorimeter walls even if it is covered, and another is that the stem of the thermometer is exposed to the temperature of the surrounding air. Both of these sources of error will tend to give a temperature reading lower than it should be. This reading is represented by T in the formula. The difference between the reading as it should be and that which is actually the case is known as the error of the instrument.

It is well, therefore, to determine what the error of the instrument is and to make a chart of corrections on section paper, as shown in Fig. 4. Let it be assumed that the steam plant is not in operation and that the steam present in the boilers and piping is dry or "dead" steam. If the steam is dry, it can be calculated what the normal gage readings should be, by subtracting the temperature at A from that at C, which will be zero, or atmospheric pressure, and divide the remainder by the specific heat of superheated steam at atmospheric pressure, or 0.48, and add the result to 212, the temperature of steam at atmospheric pressure. For the following pressure the normal readings are:

Pounds, gage	Degrees F.
20	246 4
40	264 3
60	276 1
80	285 1
100	292 2

Now take a piece of sectional paper and under the lower line lay off values for steam temperatures. Then plot the foregoing values and draw the "curve of normal readings" through these points as shown.

At some convenient time when the steam is "dead" and supposedly dry saturated, regulate the pressure in the pipe to the values referred to; that is, 20, 40, 60, 80, 100 lb. Then turn steam into the calorimeter and note the temperature registered by the thermometer after the steam has flowed for about four minutes and is constant. It will be seen for each pressure that the values will be lower than the calculated ones. For example, assume that these values would be

Pounds, gage	Degrees F.
20	230
40	243
60	251
80	256
100	262

With these values plot the second curve or "curve of actual readings." This will give a chart showing the error of the instrument for all temperatures likely to occur. Suppose that the calorimeter is in actual use and that the percentage of moisture in steam is being determined, the thermometer shows 240 deg. F. This is the actual reading and lower than the normal reading in the formula.

Referring to the chart, a point is found on the lower curve corresponding to this value, and directly above it on the normal reading line is the value 261 deg. Then

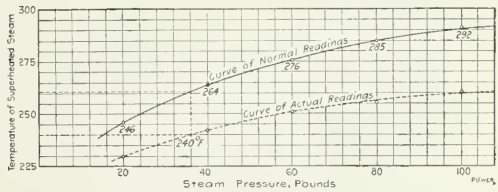


FIG. 4. CURVES OF NORMAL AND ACTUAL READINGS

when working out the formula used for T, not the actual reading 240 deg. F., but the other, 261 deg. F. This will give the corrected temperature reading and take care of all radiation and other losses of heat in the calorimeter which will be close enough for general purposes. It should be remembered that the figures assumed for the curve of actual readings are given only as an example. Each calorimeter will give different values and these must be determined for each instrument. The values worked out for the curve of normal readings should be used.

The N. A. S. E. Convention

Ideal convention weather, an ideal convention city and large and enthusiastic attendance, including 412 accredited delegates, combined to make the thirty-first annual gathering of the National Association of Stationary Engineers at Springfield, Mass., one of the most successful in the history of the organization. In a city like Springfield the convention is not absorbed as it is in a metropolis. The people know that it is there and enter into the spirit of it and the mayor does not send an understudy but comes himself to welcome the visitors and takes a human interest in their presence. At Springfield were present not only the mayor of the city itself but those of the neighboring cities of Lawrence and Northampton.

The visitors were gracefully welcomed by Mayor Denison, and speeches were made by representatives of the Board of Trade, the Publicity Club and the mayor of Lawrence, which were fittingly responded to by President McGrath, Vice-President Coe and Past President Kearney. The local speakers showed in their remarks an unusual degree of familiarity with the objects and methods of the association and of acknowledgment of its high mission and practical importance as an industrial factor. The president's annual report commended the work of the educational committee, condemned carping criticism of the methods of the association and recommended the continuance of the present program until something infinitely better is developed.

In order to secure better efficiency and more conformity in the work of the state associations he recommended that the programs of their annual conventions be submitted to the national president in advance for approval, which recommendation was adopted. A suggestion that the reports of the subordinate associations be sent direct to the national secretary instead of to the deputies was defeated.

The secretary's report showed the membership to be something over 21,000, and the treasurer's report showed a balance in favor of the association of over $27,000, of which upward of $18,000 was required to pay the mileage of the delegates.

The Life and Accident Association shows a membership of 3587, an increase of 346 over that of last year. Its disbursements during the year, outside of benefits paid, have been less than one dollar per member and it has over $5000 in reserve. J. D. Taylor was reëlected secretary-treasurer and J. G. Beckerleg and T. N. Kelsey as trustees.

In response to 340 letters sent out by a committee appointed by resolution of the last convention "to consider the matter of biennial conventions of this national body and report at the next annual meeting," only 162 replies were received, of which 116 voted against biennial and 45 in favor of the two-year plan with one tie vote. The committee simply reported these facts without recommendation.

A committee appointed to consider the advisability of publishing a history of the association, reported that "in the office of the national secretary there is a continuous record of convention proceedings from which might be compiled a digest of the legislative work of the N. A. S. E., which would be of value as a work of reference." They did not favor the writing of a history for the reasons "that the association has not been in existence long enough to warrant a written history; that there is no real demand for such a history; that it would require a considerable sum of money to publish a history, the sale of which is a matter of mere guesswork."

The president decided that the New England States Association had no legal standing, and was supported by the convention. A resolution authorizing the organization of district associations was defeated.

The License Committee reported in detail the efforts which had been made to secure legislation providing for the examination and licensing of engineers during the past year. The net result was the passing of the New Jersey law, of which we have already treated at length, without any appropriation to make it effective; an amendment to the Pennsylvania law, making it mandatory upon all cities of the third class to pass ordinances requiring the licensing of steam engineers, and to create departments of boiler inspection; a state law in California similar to that of New Jersey, and ordinances in Geneva, N. Y., and Decatur, Ill. The convention adopted a recommendation of the Ways and Means Committee that an amount not to exceed $2000 be set aside to assist cities

Delegates and Guests at the National Association of Station

and states in securing license legislation during the coming year. The compilation and publication in book form of all existing engineers' license and boiler-inspection laws and ordinances was authorized.

The trustees of the *National Engineer*, the organ of the association, reported the paper in flourishing condition, having netted the association over $17,000 the past year. They protested against the publication of the directory of officers and associations, because it afforded to those who might otherwise patronize the paper a means of reaching the membership without doing so. They declared that "the practice of soliciting so called donations from our patrons, which is in reality a form of advertising by the exhibition of business cards in the association rooms, picnic tickets, etc., is bringing to us adverse criticism from many quarters" and strongly urged the discontinuance of this practice. They recommended that a sum not to exceed 25 per cent. of the net income of the paper be rebated *pro rata* as per capita tax paid, and per-

Second, $50—William T. Frizzell, Massachusetts, No. 16.

Third, $30—H. E. Pressinger, Wisconsin, No. 18.

Honorable mention—A. Wade, Illinois, No. 28.

ELEMENTARY CONTEST

First, $50—Charles E. McLean, Lowell, No. 17.

Second, $30—John O. Burman, Lowell, No. 17.

Third, $20—Norman S. Campbell, Michigan, No. 1.

In the second or March to June contest there were 18 papers submitted, 7 in the elementary and 11 in the advanced. The winners were:

ADVANCED COURSE

First, $75—R. B. Ambrose, Pennsylvania, No. 3.

Second, $50—H. E. Pressinger, Wisconsin, No. 18.

Third, $30—Martin O'Connor, Wisconsin, No. 1.

ELEMENTARY COURSE

First, $50—C. B. Hudson, Massachusetts, No. 17.

ERS' CONVENTION AT SPRINGFIELD, MASS., SEPT. 8 TO 13, 1913

haps the most important act of the convention was to adopt this recommendation.

During the year 182 members of the association have passed away and the delegates stood in impressive silence while their names were read by the secretary.

A feature of the convention was an address by Edward F. Miller, professor of mechanical engineering at the Massachusetts Institute of Technology and leading member of the Advisory Educational Board of the N. A. S. E. He traced the development of the civil from the military engineer, the growth of power as a factor in industry and civilization and of the men concerned with its production.

J. D. Taylor told of the efforts which were being made in New York to secure uniformity in rates for electric service and prevent the sale of current at less than cost to put isolated plants out of business. George H. Diman, of Lawrence, Mass., was accorded the floor as an honorary member and advised the delegates to work for a flat rate and the prevention of discrimination, which was of more moment to them than license laws, with which he has little sympathy.

The Educational Committee reported that 33 members had competed in the first or December to February Prize Question Contest, 20 in the advanced and 13 in the elementary. The prizes were awarded as follows:

ADVANCED CONTEST

First, $75—Frederick L. Ray, Kentucky, No. 3.

Second, $30—John Guilfoy, Massachusetts, No. 16.

Third, $20—divided equally between J. O. Burman and C. E. McLean, of Massachusetts, No. 17.

A second activity of the committee was to offer four prizes for meritorious work in association meetings. The conditions were that the meeting should be of educational nature, that the members should take part in the discussion and that a report of the number present should be sent to the Educational Committee by May 1. "This competition," says the committee, "was advertised twice, but apparently it was not received very enthusiastically by the associations. At any rate there were only three entries—two of these from the same association. The prizes announced were to be of equal value with no mention of first, second, etc., and the original announcement was to the effect that the prizes would probably consist of steam-engine indicator outfits. The best entry was that of Illinois No. 1 for a meeting held on Jan. 15, 1913, when A. R. Maujer, of Illinois No. 1, gave a lecture on 'Proximate Coal Analysis and Its Value in Power-Plant Economy.' Judging from the report received from the officers this meeting was a most successful one—139 members and friends were present, and 21 took part in the discussion which followed.

"The second meetings in order of merit were those of Kentucky No. 1. This association reported two meetings, one on Nov. 27, 1912, and another on Mar. 12, 1913. At

he meeting of Nov. 27, D. L. Fagnan, of the De La Vergne Co., lectured on 'Oil Engines,' before an audience of 58 men. The discussion was mainly in the form of questions and was not in the same class as that of Illinois No. 1; nevertheless, we recommend the awarding of a prize to this association and it will be left to the national president to make both awards."

The committee reported that the Information Department, which acts in a consulting capacity for solving plant problems presented by the members, had found much favor. About 75 problems were presented to the department throughout the year.

Another successful innovation was the distribution of lantern slides to be used by local members in lectures. Sets of slides dealing with turbine, boiler and gas engine have been distributed and one on refrigeration is in preparation. When this is finished the association will have 2550 lecture slides. The committee recommended the continuation and extension of the lantern-slide collection and system of lectures and of the Information Department, the continuation of the offering of prizes for answers to questions for another year; a subdivision of lantern-slide sets; the continued award of prizes for well attended educational meetings, the discussion to be a factor in making the award; the urging of state associations to take up the work offered by the National Educational Committee. A sum not to exceed $3000 was appropriated for these purposes.

Mesdames Heckler and Mullen, president and past president of the Ladies Auxiliary, visited the convention, described the work which they were doing and made a plea for continued support, especially of the pension department, which had collected more than $2100 and disbursed more than $1500 to the pensioners during the last year.

The newly elected officers of the auxiliary are: Mrs. Sophie Whalen, of Chicago, president; Mrs. Hunt, of Boston, vice-president; Mrs. Frank Flynn, of Chicago, secretary; Mrs. Herbert E. Stone, of Framingham, treasurer; Mrs. Huntington, conductor.

Of eight cities which wanted the convention next year, Milwaukee was selected. This will be the third time, the first being in 1900.

The officers elected for the ensuing year are James R. Roe, of New York, president; Frederick L. Ray, of Louisville, Ky., vice-president; Fred W. Raven, of Chicago, secretary; Samuel B. Forse, of Pittsburgh, treasurer; Joseph F. Carney, of New York, trustee of *National Engineer;* John J. Reddy, of Jersey City, conductor; John A. Proper, of Los Angeles, doorkeeper.

The social features comprised a reception by the national officers on Monday evening, a visit to the works of the Chapman Valve Co., a gigantic clam bake, at which over 1900 people were served, a smoker, a vaudeville performance, afternoon concerts and teas and a grand ball following upon a public installation of the officers.

The exhibition conducted by the National Exhibitors' Association in connection with the convention occupied two floors of the large municipal auditorium and was well attended by local engineers as well as by the visitors.

There was an unusual number of operative exhibits which attracted particular attention, such as two full-sized Corliss engine models operated by motors, traps and high- and low-water alarms in operation, a device for testing the relative friction of packing on 3-in. rods, autogenous welding, cutting, etc. A local welding company subjected a 30-in. vertical firebox tubular boiler made of ¼-in. stock entirely by welding to hydrostatic pressure and it developed a leak in the welded-in door frame at 305 lb., due to the inward bulging of the unstayed firebox. As the boiler was designed for heating service under 10 lb. pressure, the test was regarded as very unsatisfactory.

The newly elected officers of the Exhibitors' Association are Homer Whelpley, of Cleveland, president; Henry Pastre, of Pittsburgh, vice-president; Lane Thompson, of Cincinnati, secretary; Harry D. Raymond, of Boston, treasurer; Charles Cullen, of Cincinnati, Charles A. Wilhoft, of New York, Paul T. Payne, of Chicago, Joseph H. Meyers, of Cleveland, and John H. Foote, of New York, members of the executive committee.

It goes without saying that retiring officers and those who had especially contributed to the success of the convention were remembered in resolutions of thanks and more substantial testimonials, including a handsome watch to Walter Damon, who had been untiring in his efforts to bring the convention to Springfield and as chairman of the local committee fulfilled all of the anticipations which he had aroused.

Determining Reducing-Valve Sizes

By J. Rowland Brown

A large percentage of the troubles experienced with steam-pressure regulating or reducing valves can be traced directly to the use of valves too large for the service conditions they are required to meet. It is common practice when installing a regulating valve in a heating system or on a cooking apparatus to use a valve of the same size as the pipe leading to the system. An exception to this practice is in vacuum-heating systems where it is customary to install a valve of one-half the diameter of the service pipe and have the outlet of the valve twice the size of the inlet of the port. This latter case, while a move in the right direction, may be in serious error.

The correct way to determine the size of a regulating valve is to find the weight of the steam required per hour and then choose the valve that will most nearly deliver that quantity of steam at the required pressures. The objection to this scheme is that it is often difficult or impossible to determine the weight of steam required.

The following is a description of a scientific method of approximating the correct size of valve, and, though only an approximation, it has proved, when tried in some hundreds of cases, to be seldom in error.

The upper curve, Fig. 1, shows the relation between the specific volume of saturated steam and its absolute pressure, and the lower curve represents the relation between the square root of the specific volume and the absolute pressure. It is readily seen from an inspection of the upper curve that the volume of a pound of steam is very great at low pressures and decreases very rapidly as the pressure rises up to about 75 lb. absolute and then decreases very slowly. As an example, 1 lb. of steam at 100 lb. absolute pressure will occupy 4.4 cu.ft.; if its pressure is reduced to 50 lb., it occupies 8.4 cu.ft.; to 25 lb. 16 cu.ft., and at atmospheric or 15 lb. absolute pressure it occupies 26 cu.ft.

The quantity of steam that should flow through a pipe

s generally figured by assuming some velocity of flow, nd then knowing the pressure and specific volume, the veight per hour is calculated.

Let

A = Area in square feet of the pipe or passage;
V = Velocity of steam in feet per minute;
S = Specific volume of saturated steam in cubic feet per pound;
D = Diameter of pipe or passage in feet.

The pound of steam flowing through the pipe per minute s equal to

$$\frac{A \times V}{S} = \frac{0.7854\ D^2 \times V}{S}$$

In the case of a valve having the same size of inlet and outlet, the number of pounds of steam per minute leaving the valve is the same as the number entering, and here is the following relation:

$$\frac{A \times V}{S} = \frac{A \times V_1}{S_1} \text{ or } \frac{V}{S} = \frac{V_1}{S_1} \text{ or } \frac{V}{V_1} = \frac{S}{S_1}$$

In other words, the ratio of the inlet and outlet velocities s equal to the ratio of the inlet and outlet specific volumes. In a regulating valve having an equal size inlet nd outlet this accounts for the fact that the velocity

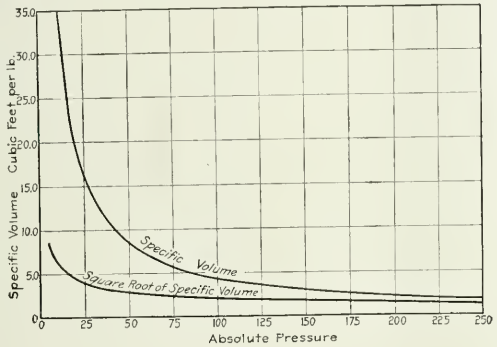


Fig. 1. Pressure-Volume Curves

is higher in the service or outlet pipe than it is in the initial or inlet pipe. There is no economy in having the velocity in the inlet pipe lower than that in the service pipe, as a smaller inlet pipe and a smaller valve will do the work. The port of the valve should in all cases be the size of the inlet pipe, if the pipe is the correct size. The greatest economy exists when the velocity of steam is the same in the inlet and outlet provided the outlet velocity is correct.

In the case of the inlet and outlet velocities being equal, the ratios are

$$\frac{A \times V}{S} = \frac{A_1 \times V}{S_1} \text{ or } \frac{A}{S} = \frac{A}{S_1} \text{ or } \frac{A}{A_1} = \frac{S}{S_1}$$

in other words, the ratio of the inlet and outlet areas is equal to the ratio of the inlet and outlet specific volumes.

To find the ratio of the diameters:

$$\frac{A}{A_1} = \frac{0.7854\ D^2}{0.7854\ D_1^2} = \frac{D^2}{D_1^2}$$

$$\frac{A}{A_1} = \frac{S}{S_1} = \frac{D^2}{D_1^2} \text{ or } \frac{D}{D_1} = \frac{\sqrt{S}}{\sqrt{S_1}} \text{ and } D = D_1 \frac{\sqrt{S}}{\sqrt{S_1}}$$

that is, the ratio of the diameters of the inlet and outlet pipes is equal to the ratio of the square roots of the specific volumes; or the diameter of the inlet pipe or the regulating-valve port is equal to the product of the diameter of the outlet and the ratio of the square roots of the specific volumes.

It is necessary, therefore, to know the size of the outlet pipe and the initial and service pressures, and by referring to the curve, Fig. 1, the square roots of the specific volume can be found.

The single assumption made in this problem is that the service or outlet pipe is of the correct size. This formula insures a valve of such size as to give the same steam velocity at its inlet and through an inlet pipe of the same size as that in the outlet or service pipe, and, therefore, provides a smaller valve than would ordinarily be selected. The use of the smaller valve is, of course, cheaper in first cost, and because of the main valve being wider open and there being less wire drawing or cutting of the seat, the valve should last longer. There is also a decided advantage in operation as the smaller valve will have a greater lift of disk for a given amount of steam flowing and is, therefore, not disturbed by vibration, sticking or pressure changes to as great an extent.

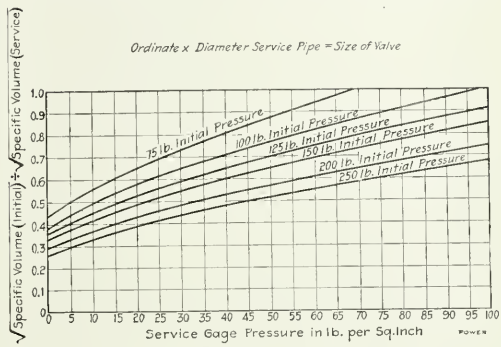


Fig. 2. Curves for Determining Sizes of Reducing Valves for Given Service Pressures

It is difficult to get good, continuous regulation when a valve is just cracked off of its seat.

Referring to the lower curve, Fig. 1, and to the formula

$$D = D_1 \frac{\sqrt{S}}{\sqrt{S_1}}$$

take, as an example, a 12-in. service pipe with a pressure reduction of 145 lb. to 1 lb. gage pressure, or 160 lb. absolute to 16 lb. absolute.

$$D_1 = 12\ in. = 1\ ft. \quad \sqrt{S} = 1.7 \quad \sqrt{S_1} = 5.0$$

and $D = 4.08$, which is very close to a 4-in. valve, which would be the size to use.

To make the above operation easier, the curves, Fig. 2, were drawn, in which the ordinates represent the ratio $\frac{\sqrt{S}}{\sqrt{S_1}}$ and the abscissas the service pressure recorded by the gage (not absolute).

To use the curves, first find the service pressure at the bottom and follow the vertical line until it intersects the

urve of initial pressure; then follow the horizontal line rough this intersection to the left and read the corre- onding number. The number at the left multiplied y the size of the service pipe (in inches) will give the ze of the inlet pipe and valve.

As an example, take the case of a 4-in. service pipe nd a reduction of 75 lb. gage to 20 lb. Read 20 lb. at ie bottom of the curves, then follow the vertical line ntil it intersects the 75-lb. curve, next follow horizontal- to the left and the reading is 0.64. Multiply 0.64 by , the size of the service pipe, and the result, 2.56 in., the size of the valve. The nearest commercial size of alve and inlet pipe would, of course, be 2½ in.

Fire-Fighting Talks to Engineers

On Monday evening, Sept. 8, about 1800 factory fire chiefs, any, if not most of them, chief engineers, listened to instruc- ve talks by Colonel Bryant, Commissioner of Labor, of New ersey, and ex-Chief Croker, of the New York Fire Depart- ent, at the Krueger Auditorium, Newark, N. J. Several xcellent lantern-slide illustrations of factory fire-fighting pparatus, such as pumps, etc., were shown.

NEW PUBLICATIONS

LECTRICITY FOR THE FARM AND HOME—By Frank Koester. Published by Sturgis & Walton Co., New York, 1913, as part of the "Farmers' Practical Library." Size, 8x5 in., 279 pages, illustrated. Price, $1, net.

The application of electricity to farm work has been ouched on from time to time in various magazines, but this , insofar as we know, the first extensive treatment of the ubject in book form. It is a book which should appeal to very progressive farmer.

The author points out the three possible sources of elec- icity for this purpose. First, high-tension transmission nes from large central stations often pass through farming ountry and these can very easily be tapped and the voltage epped down through small transformer stations to supply ne or a group of farms.

The second plan is to establish rural central stations. his practice has been followed to a large extent in Germany, uch stations often supplying from 100 to 150 farms. Where ural central stations are not feasible and where no trans- ission lines pass in the vicinity, the farmer may, providing s work is extensive enough, put in an isolated plant. This often advantageous where there is water power available n the premises. Typical installations along this line are ted.

A chapter is devoted to various motor applications in farm ork, and rules are given for determining the sizes of motors be used. Useful cost figures are also included.

The book concludes with suggestions for electric heating nd lighting on the farm.

AYING OUT FOR BOILER MAKERS AND SHEET METAL WORKERS—SECOND EDITION. Published by the Aldrich Publishing Co. ("The Boiler Maker"), New York. Cloth; 306 pages, 10x13 in.; 600 illustrations. Price $5 postpaid.

Those having a copy of the first edition will not need to e told that it is an excellent work on the subject, giving a practical way all the information necessary to enable ne boilermaker to lay out in detail different types of boiler, nk, stack and irregular sheet metal work. The first two hapters explain the methods of laying out by orthographic rojection and triangulation and problems are given to il- strate the work. In the chapters dealing with the layout f different types of boiler more space is given to the plain ubular type as the problems are general and may be ap- lied to almost any other type. Rules for determining the ze, shape and strength of the different parts are also in- uded. In the second edition 113 additional pages have een added, comprising 44 new laying out problems and hapters on miscellaneous calculations and tools for boiler akers. The problems cover a wide range of work, showing ne layout and construction of regular and irregular elbows, ipe connections, transition and offset pieces, taper courses, piral pipe, hemispherical water tanks, firebox wrapper sheets or locomotive boilers and smokestack collars, uptakes and smokeboxes for Scotch boilers. The miscellaneous calculations referred to, show how to figure the efficiency of riveted joints, the area of circular segments and the cost of boiler construction. For simplicity and breadth of treatment, anyone interested in the work outlined must need go far to find a better book on the subject.

STEAM ENGINEERING—A Text Book. By William B. King. Published by John Wiley & Sons, New York City and London. Cloth; 439 pages, 6x9 in.; 177 illustrations. Price, $4, net.

The book is a simple and straightforward treatment of the principles and action of steam boilers, reciprocating engines, turbines and the accessories, requiring no extensive knowledge of physics or thermodynamics. With so broad a field the treatment must naturally be brief, but is by no means too much condensed for a ready and clear understanding of the subjects discussed. The thermodynamics and kinematics involved are made so simple that previous knowledge of the subjects is not necessary. The table of contents following will give some idea of the compass of the book: Chapter I, Introductory; Chapter II, Application of Heat to Water; Chapter III, Fuels and Combustion; Chapter IV, Steam Boilers, Attachments and Accessories; Chapter V, The Slide Valve and Its Motion; Chapter VI, Rotary Motion, Action of Crank and Connecting Rod; Chapter VII, The Reciprocating Steam Engine, Types and Details; Chapter VIII, Condensers, Feed-water Heaters, Pumps; Chapter IX, The Indicator and Its Diagram, The Planimeter, Clearance, Ratio of Expansion; Chapter X, Expansion of Gases, Mean Pressure of an Expanding Gas; Chapter XI, Compound or Stage-Expansion Engines; Chapter XII, Boiler Efficiency, Calorimetry; Chapter XIII, Engine Efficiency, The Carnot Cycle; Chapter XIV, Design of Simple and Compound Engines; Chapter XV, Combining Diagrams of Stage-Expansion Engines; Chapter XVI, The Zeuner Valve Diagram; Chapter XVII, Entropy; Chapter XVIII, The Steam Turbine; Chapter XIX, Testing Engines and Boilers; Index.

Of superheated steam the specific heat is no longer taken at the constant value of 0.48. Recent experiments have shown that it varies with the temperature and the pressure. The author has used the older value and in the first two chapters values from the older steam tables, although in the balance of the book the Marks and Davis values have been adopted.

It is, of course, best to be uptodate and consistent on data of this character. Aside from this the book is the best we have seen in many a day. It is simple and explicit, and gives what is wanted in a nutshell. It should be an excellent work for a short course or for an introduction to subjects to be taken up more in detail later on. As a reference to refresh the memory and give all that is necessary in a short space, a better book could not be obtained.

SOCIETY NOTES

The evening courses offered by Pratt Institute will open on Oct. 1. The courses are technical chemistry, mechanical drawing, industrial electricity, practical electricity, steam engine, strength of materials, practical matnematics, machine work and tool making, carpentry and building, pattern making, sheet-metal work, plumbing, trade teaching. A circular of information may be had by writing to School of Science and Technology (Dept. N), Pratt Institute, Brooklyn, N. Y.

PERSONALS

C. F. Catillaz, the New York representative of Neemes Brothers, has moved into his new office at 30 Church St., New York City.

Henry D. Jackson, consulting engineer, Boston, Mass., sailed Sept. 20 for Bermuda on a three-months' trip for rest and recreation.

R. A. Foresman has been appointed supervising engineer of the Eastern Pennsylvania Power Co. plants, with headquarters at Easton, Penn.

William Tietze, formerly chief engineer of the Power Mining & Machine Co., Cudahy, Wis., and now with the Pierce Phosphate Co., Pierce, Fla., has been appointed chief engineer with this company.

POWER

Vol. 38 NEW YORK, SEPTEMBER 30, 1913 No. 14

How One Engineer Got His Job

Here is a plain unvarnished tale. Perhaps it is commonplace. But it is the commonplace that is oftenest vital.

The story begins when our hero was chief of a small-town water-works.

He had been there three years and was receiving $1400 per year. Being amply capable for the requirements of the position, conscientious and mildly ambitious, the need of bending to the whims of amateur supervision and conforming to petty political restrictions became somewhat irksome and he decided to cast about for a berth at least more congenial if not more remunerative.

A classified ad in a daily of a nearby large city brought a letter one morning which stated that if he was familiar with the installation and operation of apparatus usually found in a small plant it might be to his advantage to call on Mr. X.

After an interview long enough to convince Mr. X that the candidate was thoroughly competent, the former suggested that they look over the plant, situated in the basement of a recently erected six-story loft and manufacturing building and consisting of three tubular boilers, two small generators and the usual complement of other apparatus.

When the engineer saw that the plant was well arranged and that its operation would obviously be satisfactory from every viewpoint, he decided he wanted the position even at a lower salary. But, getting down to terms, the owner rather discouraged him by saying, "I'll give you $1000 the first year and a raise of $100 each succeeding year."

"Such terms are out of the question."

"All right," replied Mr. X, "I'll have to get another man. A half dozen have been in here, any one of them willing to work for $900."

"I don't doubt that," said the candidate. "If you wished, you could get a man for $780. But to hire a low-grade man to take charge of your new, high-grade machinery, simply because you can get him for little money, is shortsighted indeed. You didn't buy the cheapest equipment you could; you gave some weight to service and efficiency. Now, in buying the services of an engineer it is doubly important to secure efficiency, because while a good engineer may be able to get fair results with poor equipment, a poor engineer can never get even ordinary results with a first-class plant."

"Your argument sounds good," said Mr. X. "I'll tell you what I'll do. I'll give you $1100 per year to start."

"In view of my present circumstances, that is not satisfactory," said the engineer, "but I will start on that basis on two conditions. First, if, after three months, you will raise my salary $10 per month if my work proves satisfactory; if not, you are to pay me off and that will be the end of the matter. Second, if you will give me all I save in the cost of fuel for one year, based on normal operating conditions."

After taking two days to think it over, Mr. X agreed to this proposition.

This engineer has had the position for three years now, is receiving $1460 per year, and the end is not yet. Besides, he received $254 for the coal saved during his first year's operation.

In addition to the management and operation of the power plant, he has complete charge of the building, acting as Mr. X's personal representative.

Mr. X will shortly erect another building requiring a separate power plant. The supervision of the new plant will fall to the present chief and the added responsibility will unquestionably bring increased remuneration.

This engineer's work is congenial; he suffers few annoyances and no indignities. He is young, steady going and industrious. His future is assured.

Many an engineer drawing double or even treble this man's salary may well be envious.

Good Record for Small Isolated Plant

By F. L. Johnson

YNOPSIS—With a rate of 2c. per kw.-hr. for power nd 8c. for lighting from the central station and doing s own heating, the Renton Heel Co. decided to install 75-kw. generating set. With coal at $3.50 per ton it ade a gross annual saving of 27 per cent., or a net rning on the investment of 18 per cent.

Whenever a change is made from central-station to ivate-plant service, or the other way, the operating en- neer is always interested, not only in the reasons which d to the change, but also in the results of that change. in number, varying in capacity from 1 to 15 hp., and totaling in the aggregate about 60 kw. By Jan. 1, 1912, the plant was operating at near its full capacity of 100,000 pairs of heels and 60,000 pairs of counters daily. Current was supplied by the central station at the rate of 2c. per kw.-hr. for power and 8c. per kw.-hr. for lighting. Steam for heating, drying and other purposes was furnished by one of the two horizontal return-tubular boilers which were installed at the start.

As the coal and power bills came in each month, it was seen that central-station current was proving to be an

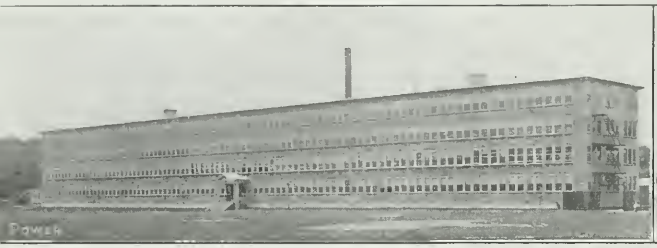


Fig. 1. Factory of the Renton Heel Co.

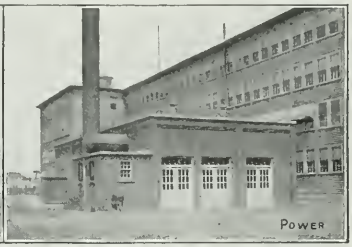


Fig. 2. The Power House

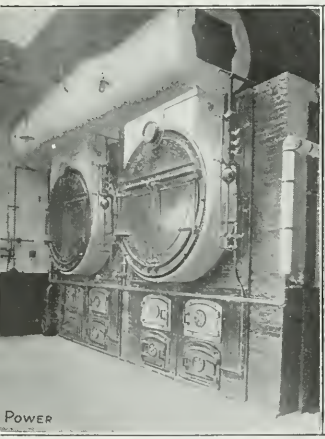


Fig. 3. Hodge Boilers Equipped with Coppus Blowers

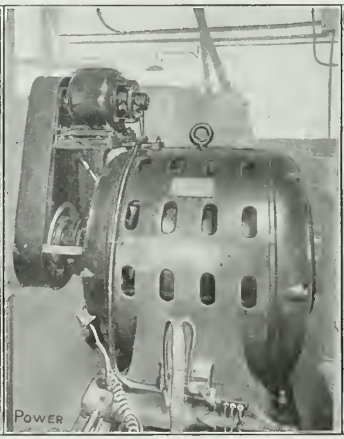


Fig. 4. Wagner 75-Kw. Alternator with Belted Exciter

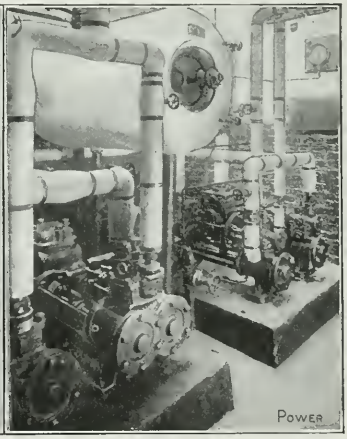


Fig. 5. Boiler-Feed and Vacuum-Return Pumps

When in 1911 the Renton Heel Co., of Lynn, Mass., decided to erect a new factory building, the management having in view the small amount of power required, was somewhat uncertain whether it would prove cheaper to buy or generate the current used. In erecting the boiler house, room was left at one end for the installation of a high-speed engine with a direct-connected generator if it should become evident that it would pay to generate current instead of buying it.

Early in December, 1911, the new four-story factory of the company containing about two acres of floor space, was equipped with Wagner induction motors, some thirty expensive luxury during those months in which it was necessary to buy coal for heating purposes, and after several consultations with local engineers operating isolated plants the management decided to put in a steam-driven generator.

During the preliminary work involved in the selection of suitable apparatus, it developed that a high-speed engine and generator would cost a great deal more than a medium-speed engine and belted generator. As the floor space provided for the generating unit was rather limited for the larger engine, it was necessary to run the belt back past the engine cylinder and mount the exciter on

the armature frame of the generator. At a cost of $9000 for foundations, generator, piping, switchboard, belting and necessary wiring to connect the new system with the old, the generating plant was installed.

After a few preliminary runs, the outfit was put into regular service on the first working day of January, 1913, and though the story is told some months before the first full year of private service is accomplished, the cost may be compared with the corresponding period of the preceding year and the sequel read as easily as though the record for the whole year was available.

Unusual care was taken in the selection of the power-plant equipment and no choice was made without deliberate discussion of details and visits to plants where the chosen apparatus was in successful operation. Following is a list of the equipment:

ENGINE—Rollins, simple, high-pressure, double-eccentric, 14x36-in., running at 128 r.p.m. Rated horsepower 168.

GENERATOR—Wagner three-phase, 60-cycle, 75-kw., 240-volt, 300-amp., running at 600 r.p.m.

EXCITER—Crocker-Wheeler, 4.3-kw., 34.4-amp., 125-volt, running at 1600 r.p.m.

BOILER—Two horizontal return-tubular, built by Hodge Boiler Works, East Boston, Mass., in 1911. Length, 19 ft. 6 in.; diameter, 72 in.; 124 tubes, 3 in. by 18 ft.; shell plates, $\frac{15}{32}$ in.; thickness of heads, ½ in.; longitudinal joint, quadruple-riveted butt, strength of joint to solid plate, 94 per cent.

CHIMNEY—Iron, 90 ft. high, 42-in. diameter. Draft accelerated, when required, by Coppus turbo-blower. Lawrence damper regulator.

PUMP—Boiler feed, two 6x4x6-in. Knowles duplex steam-driven; vacuum pumps for elevating returns to the receiver, two 5½x8x7-in. Knowles simplex steam-driven; power pumps for supplying roof tanks, three ¾x4-in. Deane, double, electrically driven; Watson injector No. 9.

Water is heated for factory service by an independent exhaust-steam heater, automatically controlled at a temperature of 170 deg. F. Both the wet and dry systems of automatic sprinkling for fire protection are employed in the several buildings. The starting control for the dry system is located in a separate building in the yard and is electrically operated and connected with the district telegraph office, so that any interference with the system or the closing of any hand valve is promptly noted and investigated.

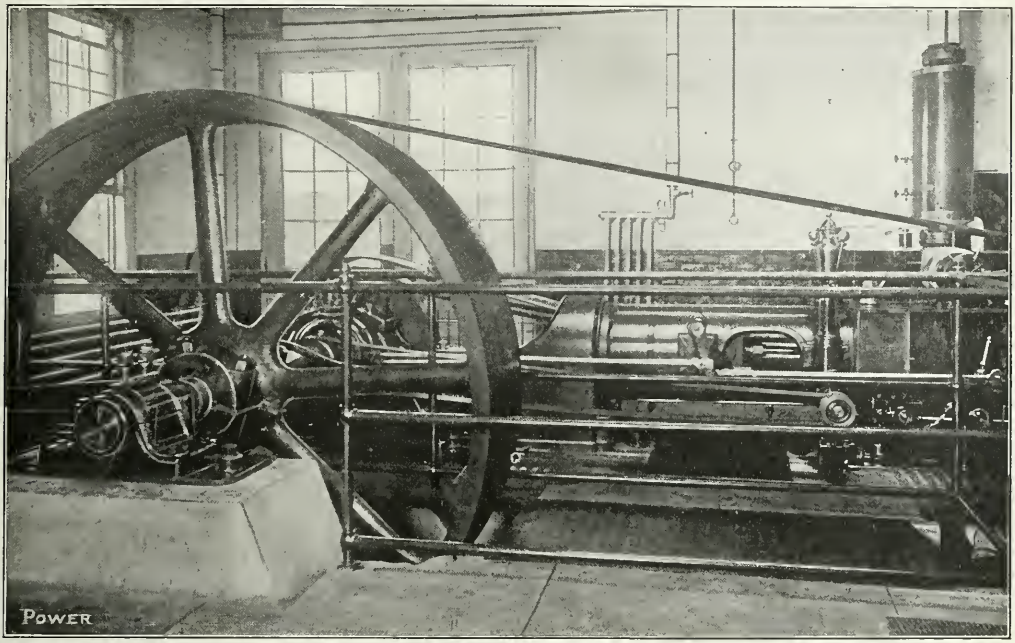


FIG. 6. ROLLINS MEDIUM-SPEED BELTED ENGINE

Complete reports of operating expenses for only the first four months of the year 1913 are available at this time, but when compared with the corresponding period of 1912, they show that even if actual loss is incurred during the four summer months of May, June, July and August, the total gain will pay a high rate of interest on the investment.

For the first four months of each of the years 1912 and 1913, the operating expenses, including coal, current, labor and supplies, were $2533.45 and $1304.84, respectively, which shows a gross saving of $1228.61.

COMPARATIVE OPERATING COSTS

	1912	1913	Gross Saving	Int. & Dep.	Net Saving
January	$771.77	$371.64	$400.13	$105.06	$295.07
February	682.84	355.38	327.46	105.06	222.40
March	587.13	306.98	280.15	105.06	175.09
April	491.71	270.84	220.87	105.56	115.81
Totals	$2533.45	$1304.84	$1228.61	$420.24	$808.37

The net profit was $808.37 for the first four months of the year 1913. It is fair to assume that the last four months will show an equal profit, and if the summer months, during which no heating is required, only pay expenses, the net profit for the year will amount to $1616.75, or about 18 per cent., on the investment after the interest and depreciation are deducted, or a gross earning of over 27 per cent.

Steam Traps on Exhaust Lines

By W. H. Wakeman

An oil separator on an exhaust pipe line running from a feed-water heater to the heating system in a machine shop is shown in Fig. 1. The drip pipe from the separator which discharged oil and grease to the sewer was made with a loop as indicated by the dotted lines. Its purpose was to prevent a waste of steam, and as long as there was a slight pressure above the atmosphere on the line it was not objectionable, although not very efficient.

The air valves on the radiators and coils in the heating system were much larger than usual and discharged into a pipe line connected with a pump. The object was to keep the line pressure below that of the atmosphere, so that when an air valve opened it would discharge water and air rapidly. Sometimes these air valves would not close promptly, hence the pressure would be reduced in the coils and radiators, also in the main exhaust pipe and separator by the operation of the pump until it was lower than atmospheric pressure. As the loop was usually nearly full of oil, etc., from the separator, it would be

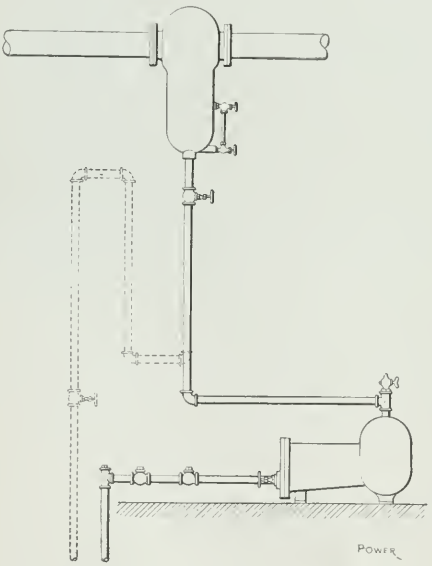


Fig. 1. Old and New Piping

drawn back into the heating system when this reduction of pressure occurred, and in due course of time appear in the boilers.

To overcome this defect the loop was removed and an ordinary ball-float steam trap installed, on the outlet of which two swing check valves were placed as shown. The arrangement operates as follows: Under normal conditions with a slight pressure above the atmosphere in the heating system, oil and water from the separator drains through the drip pipe and fills the trap until the valve opens and discharges to the sewer. When pressure

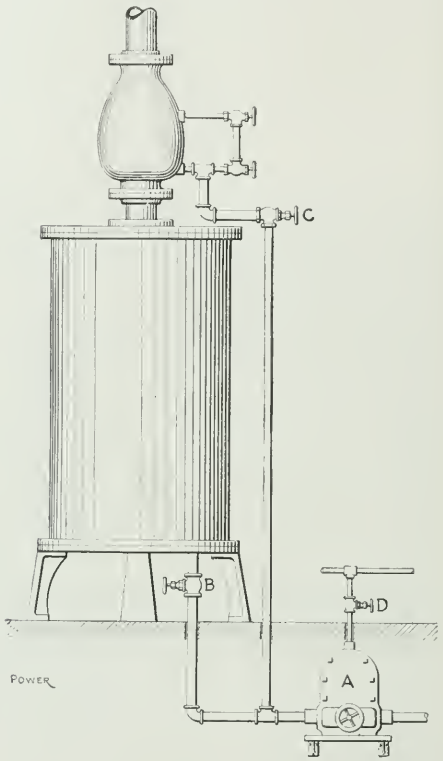


Fig. 2. Trap Connected to Heater and Drip Pipe

in the exhaust pipe is reduced below that of the atmosphere, the tendency is to draw this foreign matter up into the separator and exhaust pipe again, but the check valves close and prevent it.

The separator is about 8 ft. above the trap, and as water collects and cools it exerts 3 lb. pressure to open the check valves. This is usually more than sufficient to balance the reduction of pressure in the exhaust pipe (below atmospheric pressure), hence the trap discharges to the sewer. When this height of water is not sufficient, there can be no backward movement for the reasons already given. In practice it prevents oil from going to the boilers.

In another plant where the pressure is always equal to or above that of the atmosphere, the feed-water heater and separator were fitted with drip pipes as shown in Fig. 2, but the trap *A* was not included in the original installation. When exhaust steam was not required for heating purposes the valves *B* and *C* were left wide open, but when the engine exhausted into the heating system under 2 lb. pressure much heat was lost through these two drip pipes.

To prevent this loss the valves *B* and *C* were nearly closed until the volume of escaping steam was greatly reduced. If these valves were open just enough to allow the condensation to escape when no water was pumped through the heater, the result was satisfactory, but when the pump was started, causing much more condensation to settle to the lowest point, the nearly closed valves would not allow it to escape, and thumping and pounding in the exhaust pipe resulted. If the valves were opened enough to allow this water to escape, then much steam was lost at other times; if this water did not escape, there was the immediate danger of wrecking the engine.

To overcome this trouble the steam trap *A* was installed and now the drip valves are always open. As this trap is below the engine-room floor, a small pipe is connected to the top and extends through the floor as shown. If the trap becomes air-bound, the valve *D* is opened and the air quickly escapes. When a large quantity of water is going through the heater much steam is condensed, but the trap allows the resulting water to escape. Nothing but water that is unfit for boiler use goes to the sewer.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

SYNOPSIS—We visit several mines and see more centrifugal pumps in operation. An interesting method of hoisting mine water at a rate of 2000 gal. per min. was also investigated. The engine used to hoist this amount of water was the largest we had seen, having two 36 by 60-in. high-pressure cylinders.

Two days after my last talk with Hunter we planned to visit a mine where water was handled by a huge bucket and a winding engine. There were some things I still wanted to know about centrifugal pumps, however, for it appeared to me that with their simplicity, light weight, large capacity and ease of connection to a motor they were ideal units. From my limited observation of the two pumps I had seen operating there was no vibration or water-hammer which I had noted on the reciprocating pumps, and I so stated to Hunter.

"Right you are," was the reply. "A pump correctly balanced will run as smoothly as a watch, comparatively speaking. As you say, a centrifugal pump requires but little floor area, for the same capacity, as compared with a reciprocating pump.

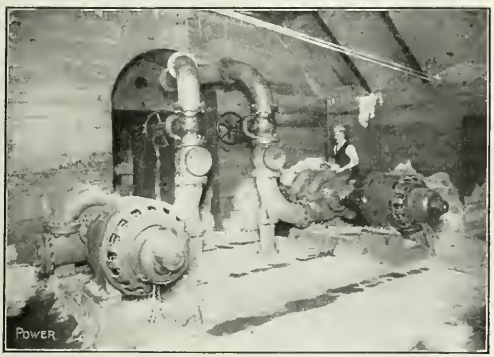


Fig. 1. Two Two-Stage Centrifugal Pumps, Capacity 1000 Gal. per Minute

"One method of running them on deep shafts is to use them as a relay system. For instance, in a shaft, say, 1400 ft. deep, the pump stations would be placed about 300 ft. apart, and each station would contain two pumps of the same capacity, one being held as a spare unit. The head would be about 325 ft. for the 1400-, 1100-, 800- and 500-ft. levels, and 200-ft. head for the pump at the 200-ft. level; each level would have a sump. The pumps would probably be of the two-stage type. In the particular mine I have in mind the capacity of each 6-in.

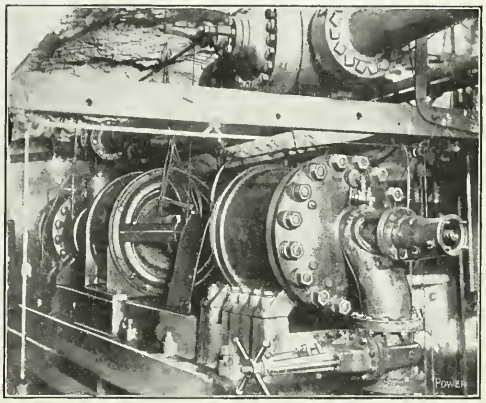


Fig. 2. Two Four-Stage Centrifugal Pumps Driven by One Motor

pump (Fig. 1) is 1000 gal. per min., with a speed of 1745 r.p.m., each driven by a 125-hp., three-phase, 60-cycle, 220-volt motor."

"So it's necessary to relay the water from one level to another. I supposed that is one of the objections to centrifugal pumps?"

"It isn't always necessary to relay the pumps," replied Hunter, "for instance, I can show you an 8-in. eight-stage pump made as one unit arranged with four stages on either side of the motor; the two sides of the pump are connected by a pipe when it is used as a series pump."

The next day we saw the pump, Fig. 2. Each set was designed for a capacity of 900 gal. per min., delivering this amount of water against a height of 1250 ft. A 450-hp. motor with a speed of 1160 r.p.m. drove the pump.

"The design of that pump," said Hunter, "eliminates a number of joints which would have a tendency to leak under pressure and the pump runner can be removed without dismantling the unit.

"As a whole, the peculiar characteristics of centrifugal umps require special care in their selection, the motor o drive them and the method of control. In some re- pects the features of centrifugal-pump operation is the pposite of reciprocating pumps."

"How do you make that out?" I asked, seating my-

Fig. 3. Two Coal and One Water-Bailer Shafts

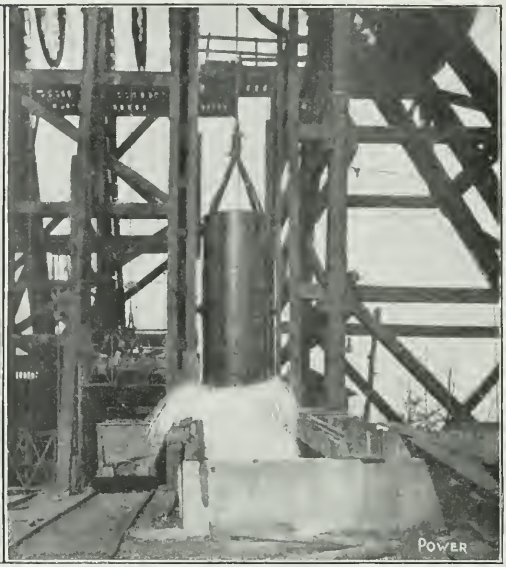


Fig. 4. Bailer Discharging Water at a Rate of 2000 Gal. per Min.

lf on a piece of timber, for the climb up the hill had een long and hot.

"Because," replied Hunter, taking a seat beside me, nd wiping the perspiration from his forehead "a con- ant speed and an increase of resistance against which e reciprocating pump works increases the pressure and e load on the water plunger. But with a centrifugal mp an increase of resistance reduces the load.

"If you are pumping a certain amount of water with reciprocating pump and wish to reduce the amount water discharged without changing the speed of the mp, some of the water being pumped must be bypassed. ith a centrifugal pump the amount of water discharged n be reduced by throttling the discharge pipe."

"According to that statement, if the head against which reciprocating pump is working is reduced, the volume scharged will not be affected, unless slightly by leakage, ut wouldn't the power to pump the volume of water reduced?"

"Right you are," replied Hunter. "With the volume scharged the power required to operate the pump will less with a reduced head. But with a centrifugal mp, when the head is reduced the volume or rate of scharge will be increased as well as the required wer, but the amount of increase in volume depends on the characteristics of the pump.

"There is this fact to always keep in mind, in selecting centrifugal pump, always know the head against which is to work, unless the motor is provided with a speed control, because a small difference in the static head will make quite a difference in the volume of water delivered; a slight variation in speed will also produce a consider- able variation in the quantity of water delivered."

After lunch we started for the mines of the Lytle Coal Co., near Minersville, where a huge mine bailer was to be seen. This shaft, or rather triple shafts (Fig. 3), is 1500 ft. deep. Coal is hoisted from two shafts, and water from the third. A 36x60-in., first-motion hoisting engine, Fig. 5, handles the mine bailer, hoisting at a rate of 2000 gal. of water per minute. The cone drum is 10 and 16 ft. in diameter. As the bailer reached the top

Fig. 5. A 30x60-In. First-Motion Hoisting Engine

of the shaft a tripper, attached to the side of the shaft, opened a valve at the bottom and the water was dis- charged as shown in Fig. 4. The tripper is shown at the sides of the bailer.

The mine superintendent stated that the mine water

was of such quality that it did not attack the pipes in the mine, which made a big difference in the upkeep expenses.

"That goes to show," said Hunter, "that nobody knows what propositions will come up when sinking a new shaft. Now, take the next mine to this one. I am told that they have all kinds of trouble with acids in their mine water, and they are not more than ten minutes' walk distant at that."

"How do you account for that?" I asked with some surprise. "I don't," replied Hunter. "I suppose that this mine being deeper has a different water to handle, or the water in the upper seams may be prevented from reaching the lower level by a layer of hard rock. The water problem in coal mines is no small matter, you may rest assured. A few of the soft-coal mines, perhaps 20 per cent., have natural drainage, in which case the cost of operating the mine is much less than if water had to be handled by pumping."

It was late that night before we returned to the hotel, tired and hungry, after a most interesting day at the mines.

Boiler Attachments—I

By J. E. Terman

SYNOPSIS—Pointers regarding the proper location of the water column and gage-glass on various types of steam boilers, kind of piping and fittings to use in the connections.

The method of applying the various attachments required for the operation of a steam boiler is an important subject. Safety is just as dependent on the correct location and method of connecting some of these devices, as it is on the design and strength of the boiler itself. However, the inexperienced engineer often overlooks the importance of the functions performed by them and does not use the caution in their installation that he would, if due thought were given the subject.

It is intended herein to relate chiefly to the equipment of the horizontal-tubular type of boiler, but some features connected with the installation of attachments on other types will be considered. As the true indication of the water level in a boiler, is one of the most important features connected with its safe operation, the proper application of devices used for this purpose will be considered first.

Water Columns and Gage-Cocks

Twenty years or more ago, and even at the present time, along some of the principal navigable streams of the country, where the equipment of the stationary plant is still influenced by steamboat practice, it is customary to dispense with a water column and have the gage-cocks located directly on some part of the boiler, for the purpose of determining the water level. In some respects this is the best kind of equipment for the purpose; for there is no reason for doubting the indications of gage-cocks when located in this manner. There are objectionable features to this arrangement, however; the principal one of which is that water is discharged over the fine or tube ends and back connection covering, when the cocks are located at the rear, or over the boiler front, if located at the furnace end. To obviate this difficulty, the cocks are frequently attached to a piece of pipe, as illustrated in Fig. 1, so that the water from the cock is discharged clear of the rear setting wall.

This arrangement is undesirable on account of two features; the small pipes are liable to be accidentally broken off or pulled out, and if the pipes happen to be dropped slightly at the end attached to the gage-cock water of condensation will collect in the pipes connected to the steam space. If the water level is tested by giving the gage-cocks a quick twist or two, as is customary, the arrangement is likely to mislead the attendant as regards the true water level in the boiler.

The modern method of equipping a boiler for the determination of the water level is by the use of a combination water column and glass water-gage, the column being usually provided with three gage-cocks. This device is so extremely simple that it is usually regarded as unnecessary to give much thought to its installation. However, the indication of the true water level in a boiler by means of a column, while simple, is a rather delicate matter, and conditions that are seemingly of no consequence are liable to cause the indications to be dangerously inaccurate. The indication of the water level in a boiler by means of a column is due to the tendency of a liquid to seek its level, or come to a uniform height in all parts of a vessel and its connections. It is necessary that the pressure throughout be uniform for the height to be the same in all parts, and slight variations of pressure in the column connections will render the level indicated false. The need for practically absolute uniformity in pressure may be realized, when it is considered that a 2-oz. difference in pressure per square inch means a change of level of nearly three and a half inches; this change of level in the horizontal-tubular type of boiler might be sufficient to turn a condition of safety into one of danger.

Pipe connections from the boiler to the column should be as short and as direct as possible, and in size not less than 1¼ in. No attachments, except a steam-gage, should be connected to the piping of a water column; and no connections for supplying steam or water should be allowed on the water-column pipes under any pretext. The slightest flow of water or steam in the pipes of a water column will render its indications of the water level absolutely untrustworthy.

Where turns are necessary in the connecting pipes to the water space of the boiler, crosses or tees should be used in place of elbows and the unused openings plugged. These plugs may be removed and the pipes cleared of scale or other foreign matter when the boiler is washed out. Fig. 2 shows a water column properly piped for a horizontal-tubular boiler with the overhanging-front type of setting.

It is necessary to have the piping from the steam space of the boiler to the water column so arranged that there

will be no chance for water pockets. It is preferable to place the piping so that the condensation will drain toward the water column rather than toward the boiler, since this will tend to keep the column and the pipes connecting it to the water space filled with condensation, and thus assist in preventing an accumulation of scale or deposit in these pipes.

No valves should be placed in the connecting pipes to a water column, because there is too much risk connected with their use. The only reason for placing valves in these connections is to allow the thorough blowing out of the pipes and the possibility of dislodging the cause of a stoppage by this means. While this is important, the necessity of such violent cleaning can be obviated, by using properly arranged connections and making periodic examinations to see that they are clean and free. A proper-sized blowoff connection to a water column will produce sufficient current in the connecting pipes to remove ordinary obstructions, notwithstanding the absence of valves on the pipes.

The danger in having valves on the connecting pipes to a water column is, that they may either be left closed accidentally or the disk may become detached from the valve stem, causing a proper water level to be indicated on them by the settling of the walls or the expansion of the boiler under operation.

It is best to use brass piping to the water column, at least on the water end, for this will not corrode and stop up as readily as will iron pipe. The connection to the steam space of the boiler will be as serviceable if made of iron as if made of brass.

The blowoff connection to a water column should be the full size of the connecting pipes, if they are not over 1¼ in. in diameter. It is usually best to have the discharge from the blowoff enter the ashpit, but the pipe should be securely fastened to the boiler front where it passes through it. Failure to observe this precaution has often resulted in injury, as the pipes are sometimes forcibly turned around on the connections, by the reaction produced by the sudden outrush of steam and water when blowing down the column.

Water columns are usually made of cast iron, and about all that is required is that they be of suitable strength and correctly arranged for the attachment of the water-gage fittings and the gage-cocks. A column should also have ample cross-sectional area to provide sufficient water storage, so that the indications of the fluctuations in the water level, produced by ebullition in the boiler, may be

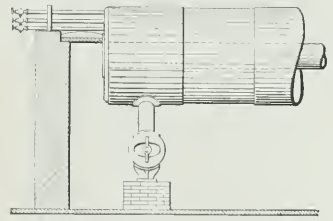


FIG. 1. GAGE-COCKS AND PIPE CONNECTIONS

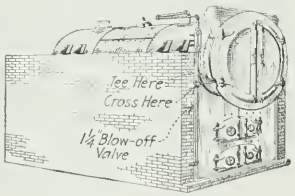


FIG. 2. BOILER AND WATER COLUMN

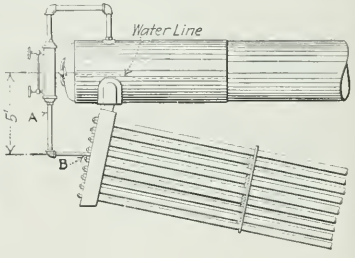


FIG. 3. IMPROPERLY CONNECTED WATER COLUMN

when in reality it is very low. There is no doubt but that a considerable number of low-water explosions could be traced to the use of such valves, if honest testimony could be obtained by those most vitally interested. No engineer, who is fit to be called such, would permit a valve between the boiler and its safety valve, and while the case is not exactly analogous, it does not appear any more logical to allow the use of such a fitting between the boiler and its water column.

With a boiler in regular operation, a warning of over pressure may be expected from the steam-gage, by the behavior of the engines or other steam-using apparatus or by leaks around the boiler or piping, before an explosion actually occurred. In the case of lack of water, only the possibility of detecting overheating could aid the attendant in preventing an accident; and it would, therefore, appear that the safeguarding of the accuracy of the indications of water level in a boiler is possibly of more importance than the correct operation of the safety valve.

When the connecting pipes of a water column are required to pass through a portion of the setting wall, as is the case with the flush-front type of setting for horizontal-tubular boilers, there should be ample clearance space left around these pipes, so that no strain can be placed

lessened. Some types of boilers require longer columns than others: for example, on a large vertical-tubular boiler the water level will fluctuate through a much wider range than on a horizontal-tubular boiler.

A 22- or 24-in. gage-glass may be found to be best suited to the former, while a 12- or 14-in. glass might be entirely satisfactory for the latter boiler. Gage-glasses are easily broken, usually by sudden changes of temperature, caused by a blast of cold air. Means must be provided for conveniently installing new glasses. For this purpose, the water-gage fittings are always equipped with valves which may be closed to prevent the outrush of steam and hot water.

There are a number of devices on the market for automatically closing the water-gage connections when a glass breaks; but these are not infallible and are liable to produce false indications of water level; their use has been wisely prohibited by the Massachusetts Boiler Rules in that state. The most satisfactory arrangement of shut-off valves for the water-gages is to equip them with chain pulls so that the valves may be closed from the floor level and save the attendant the necessity of dodging a stream of steam and hot water, as is the case when these valves must be operated directly by hand. The chain pulls are even of greater utility when opening the valves after

putting in a new glass, for the operator is out of range of the flying pieces in the event of the glass breaking. It is a dangerous proceeding to put a new glass under pressure while the face is in proximity to it, as can be attested by many an unfortunate who has been injured at such times. There seems to be an uncontrollable desire to look directly at a new gage-glass when opening the valves, to see if it will withstand the pressure. Unless chain pulls are provided for the water-gage valves, the attendant should protect his face with a shield of metal or wood, or close-woven gauze or heavy glass, if the desire to see can not be overcome. The bottom valve admitting water should be opened first; afterward the steam valve, very slowly, until equilibrium has been established, after which this valve can be opened wide.

There are a variety of good gage-cocks made, the writer preferring the type that is closed by a weighted lever provided with a piece of sheet packing which may be easily renewed as required.

Location of Water Column and Gage-Glass

A water column should always be located so that it will cease to indicate the water level before a point of danger has been reached. This means that all surfaces of water above them when there is ½ in. in the gage-glass. As an actual fact, there are several inches of water above the rear tube ends under the above conditions of water level when the boiler is in operation, due to the violent ebullition produced under running conditions.

The exact location of the safe water line in the usual type of vertical-tubular boiler can not be stated, for it depends to a large extent on the amount of grate area compared with the heating surface, and also the draft available for burning the fuel. For ordinary boilers of this type, which are usually of small capacity, the limit established by the Massachusetts rules for the minimum height of water line, viz., one-third of the tube length above the crown sheet, is probably safe. This could hardly be considered safe, however, for large vertical-tubular boilers of the Manning type, containing relatively large grate areas and long tubes, and often equipped with forced-draft appliances or stokers.

For such boilers, probably two-thirds of the tube length above the crown sheet would be required to furnish sufficient heating surface to reduce the temperature of the gases to a point which would not be likely to overheat the portion of the upper tube ends that are protected only by the steam. The safe water level for

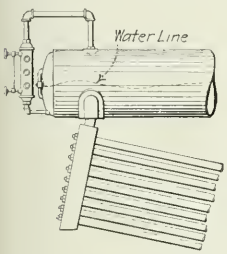


Fig. 4. Properly Attached Water Column

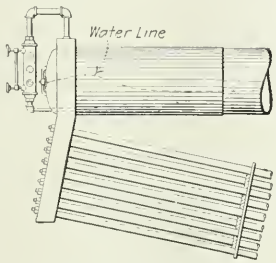


Fig. 5. Another Water-Column Connection

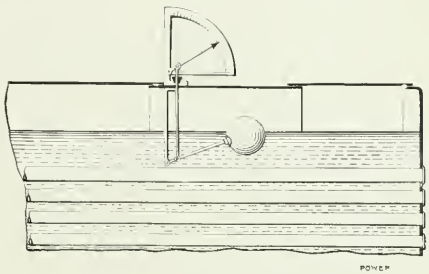


Fig. 6. Float Water-Level Indicator

swept by flames or highly heated gases should be protected on the inside surfaces by water, as long as the water-glass or gage-cocks give indications of its presence. A common and safe rule for locating the water column on a horizontal-tubular boiler is, to have the lowest point of vision in the gage-glass about one-half inch above the upper side of the top row of tubes, and the lowest gage-cock about three inches above the same point. When taking measurements for the location of the water column with respect to the tubes, it is necessary to see that the tubes are level across the boiler at both ends, and if not, suitable allowance should be made in locating the column, so that the highest exposed point will be protected.

The brick walls on the side of a horizontal-tubular boiler are generally closed in along the shell, considerably below the top line of tubes, and the rear head and tube ends are usually the first points where the effects of low water are felt. While a water level at a point as low as ½-in. above the tops of the tubes would appear as hazardous, it is not as close to the danger line as it would seem. In the first place, this type of boiler should be set with the rear end about 1 in. lower than at the front, and since the rear upper tube ends are one of the first points to require protection; this makes about 1½ in. the various types of water-tube boilers may be determined by bearing in mind the general principle that surfaces opposite those exposed to highly heated gases must be in contact with the contained water.

Care must be used in selecting a point to make the water connection to a column on a water-tube boiler, to guard against false indications being shown. Rapid currents produced by the circulation at some of the most accessible points for making such connections, might seriously affect the correctness of the indications.

In some types of boilers it is common practice to extend an internal pipe to a point where the steam has been completely liberated from the water, in order to secure a true indication of the water level.

It is a common idea that the pressures in all parts of a boiler are equal, except for the differences in pressure due to the depth below the water line at any point. While this is perfectly correct, as long as the water is in a quiescent state, it is not true under operating conditions. The violent circulation of the water in a boiler, which can not be properly appreciated, until its ability to move loose metal parts is noted, is directly due to differences of pressure in the various parts. These differences in pressure are produced by the difference in

specific gravity of the contents at various points, caused by the variations in the amount of steam bubbles mixed with the water at such points.

While the differences in pressure produced by this means may be insignificant when compared with the total pressure carried, they are very real and effective in causing incorrect indications of water level, which may become dangerous with a change of a few inches. To illustrate, suppose that the water connections to a water column on a Heine or a boiler of similar type, should be made at the center of the front header as illustrated in Fig. 3, and that the distance from the water line to the point of connection was 5 ft., as shown. Also assume, for the purpose of illustration, that this boiler was operating at a rate that would cause the contents of the header and throat connection immediately above it and up to the water line, to be one-half steam bubbles, the weight of which can be assumed as nothing, as compared with that of an equal volume of water.

Under these conditions, when the true waterline was at the center of the drum, as illustrated, the water level in the connecting pipe to the column would be at some point as at *A*, where the weight of the solid water in the pipe would just balance the pressure at the point of connection to the header *B*. Of course, there are many other factors that would affect the level of the water in the column pipe, such as, the discharge from a tube near *B;* or the velocity of the current up the header and the consequent frictional resistance to be overcome. The arrangement of the end of the pipe at *B* with respect to the currents flowing up the header would also have considerable influence on the indication of water level in the column connections, but it can be seen that a column, connected to this kind of boiler in the manner described, could not possibly indicate the correct water level while the boiler was in operation under the assumed conditions.

Other things being equal, the best arrangement for the connections of a water column to a boiler, especially if it is of the water-tube type, is to have the water connection reasonably near the waterline, for then the differences between the density of the water in the column connections and in the boiler will have the least effect on the indications shown by the column. In the Babcock & Wilcox type boiler, where there is a considerable overhang of the front drum ends beyond the header nipples, a connection directly on the steam-drum head is satisfactory. Such a connection is illustrated in Fig. 4. In the Edgemoor type of water-tube boiler it is generally necessary to connect an internal pipe to the water connection to the column, as shown in Fig. 5, to prevent interference with the indications by the circulation. In either case of the two types just mentioned, a water column connected at the rear end of the boiler would probably be more satisfactory, if it were not for the fact that it could not be readily seen by the firemen. The waterline under operating conditions, if no baffle-plates were used, is probably about as illustrated in Figs. 4 and 5 for the Babcock & Wilcox and Edgemoor type of boilers.

A water column should be blown down at least twice a day, to remove any sediment that may have lodged in the pipes, and to test the freedom of the connections by noting how rapidly the water returns to its original height in the gage-glass. When the connections to a column are free, and of ample size, there will be a constant movement of the water noted in the glass during operation. This movement is caused by the disturbance of the water level in the boiler produced by the liberation of steam, and this movement can also be used as a check against possible stoppage of the column connections or those to the gage-glass; a quiet waterline should be looked on with suspicion.

When installing a water column on a horizontal-tubular boiler, the positions that the flue doors occupy when open must be noted. If the water column can not be located in a proper position without interference by these doors, suitable stops should be provided, to prevent the doors from striking the columns when opened. It should be remembered that a water column is a most important attachment and it must be placed in a location where it can be readily seen from practically every point on the firing floor, and if the boiler room is at all dark, a light should be placed so that no mistake in reading the indications of the column can be made. The gage-glass should be kept clean, as a soiled section is liable to be mistaken for an indication of water.

There have been other devices for indicating the water level in a boiler, besides gage-cocks, and viewing the waterline through a gage-glass; but none of these attachments have proved very satisfactory. A number of years ago a float arrangement, as illustrated in Fig. 6, was used to some extent, but owing to numerous difficulties connected with its operation, it could not be depended on for correct indications of water level. It was practically impossible to maintain in good order the stuffing-box where the rod passed through the shell, so that it would be tight and at the same time free enough to permit of its being actuated by the weight of the float. There was also considerable difficulty in obtaining floats of sufficient strength to prevent collapse, without their being too heavy for the purpose. This apparatus, even when working at its best, could not give a true indication of the water line. The quadrant over which the indicating hand moved was graduated in inches and half inches.

Wydawake Damper Regulator

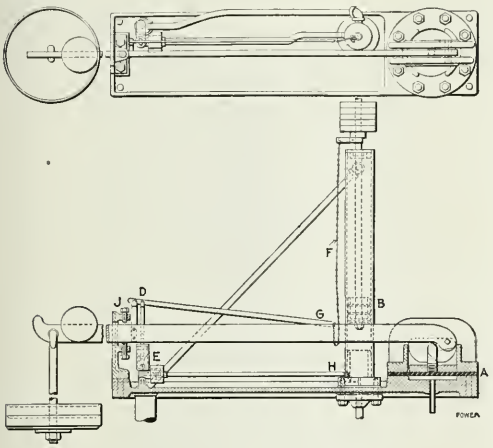
This very simple regulator has but three main parts, the cylinder with its piston, the diaphragm and the relief valve. The regulator is mounted on a heavy cast-iron base and the cylinder is of brass fitted with a piston and leather cap. There are two sets of weights, one for the main adjustment, the other for the fine adjustment. The apparatus is illustrated herewith.

In operation the steam acts on the diaphragm *A*. With the steam at the normal pressure the piston *B* will be at the bottom of the cylinder. When the steam pressure decreases under the diaphragm the main lever drops and carries the arm *D* with it, which action closes the water-relief valve *E*. This causes the water pressure to force the piston *B* toward the top of the cylinder, which opens the damper.

As the piston approaches the end of its stroke, it pulls the chain *F* taut, which lifts the short lever end *G*, and slightly opens the relief valve *E*, releasing the pressure under the piston *B*, which is held in its position until the steam pressure has reached normal at which the regulator is adjusted.

When normal steam pressure has been reached the pressure on the diaphragm lifts the main lever which action

operates the relief valve and releases the water pressure in the cylinder, and the piston descends, due to the weights on it, and closes the damper.



Details of Wydawake Damper Regulator

The water supply to this regulator, which is made by the L. J. Wing Manufacturing Co., 352 West Thirteenth St., New York City, is controlled by the screw *H*. The only other adjustment is at the screw *J*, which controls the lift of the main lever.

Experience with a CO_2 Recorder

By Henry R. Blessing

Before a CO_2 recorder was installed in my plant I used to make practical observations which, while proving satisfactory, as far as making steam was concerned, were doubtless not productive of very high economy. The water-tube boilers are fitted with vertical baffles—the last pass is down, and there are four passes. The furnaces are mechanically fired, and front-feed inclined grates are used.

Before the CO_2 recorder was set up, I made observations of the fire to ascertain the condition for steaming. I had read that a white, dazzling color is the hottest, but it was not the most economical in my case, as a light-orange color gave the best results. My explanation is that the dazzling flame carried with it an excess of air, the first pass receiving most of the heat, and with the infiltration of air through the setting, the gases in the last pass were too cool to produce good results.

I also found that a light fire would give a white, dazzling color in the furnace. All that was visible in the upper part of the first pass was the reflection from the furnace below, and nothing seemed to go over the baffle into the second pass. With a fire thick enough to produce a light-orange color in the furnace a longer flame was obtained, which could be seen going over the top of the baffle and part way down the second pass.

With this condition steam could be held better, which convinced me that the light-orange color was best suited for existing conditions. When the CO_2 recorder was installed I expected to see a high per cent. of CO_2, but the highest obtained was 3 per cent. Then I blamed the machine which recorded CO_2 only, but after testing, it was found correct.

The sampling pipe was then changed, entering the rear setting in and terminating over a division wall to the dampers. A tee was screwed on the end of the old pipe and a piece of perforated pipe screwed in each branch having a plug at each end; thus the sample was drawn from the full width of the last pass.

After this change an increase in the percentage of CO_2 was obtained, but not what was expected. Every crack was stopped up, no matter how small, in the setting, around the furnace floor frames and wherever air might leak in, after which 10 per cent. CO_2 was obtained, but no matter what was done this was the most that could be had, often less.

Later, while watching the machine record some samples, the needle registered 15 per cent. CO_2 and stayed there until it unloaded, thus recording on the chart the highest per cent. yet obtained. The recorder is in a separate room and, going to the boiler room, I found the man who cleaned the tubes had the tube blower stuck in the lower hole in the first pass just over the furnace and in line with the combustion arch.

Here was a problem to solve. Before the CO_2 machine was installed I had to increase the thickness of the fire to prevent too much air passing through the grates, and now the tube blower showed that more air was needed. It appears that before the use of the CO_2 recorder enough air leaked into the furnace to satisfy combustion. After the cracks were stopped up all air had to pass through the grate, the air spaces in which were found badly clinkered, thus retarding the air supply to the furnace.

This suggested admitting more air in front of and over the coking plate and mixing the air with the gas before it came in contact with the combustion arch, the amount of air to be regulated to suit the conditions of the grate and the kind of coal burned.

Control of Furnace Draft

By Everard Brown

The efficiency of a boiler and consequently its economical operation, depends upon the right proportion of air admitted to the furnace, or, in other words, upon a proper draft.

For the purpose of such draft regulation the damper is used in connection with natural-draft systems, and while it may not be quite as effective as some other means of regulation, it will, if properly handled, make for better furnace operation and fuel reduction.

For example, if the boilers do not have a full load, the dampers may be partially closed, thus reducing the intensity of the draft and diminishing the rate of combustion of fuel on the grates. If they are subjected to a fluctuating load, the dampers, when attached to regulators, will automatically close as the demand for steam decreases and the steam pressure increases, thus preventing the boiler safety valves from blowing. If the load is constant and the grate area is in proportion to this load, the damper becomes of less importance.

Dampers are usually located in the uptake flue and are sometimes arranged to regulate the admission of air below the grates. Two dampers, one in the flue and

ie in the ashpit, however, will probably give the best ontrol, as the former will regulate the admission of air er the fire or through the door grids, in hand-fired ilers, and the latter will control the passage of air rough the fuel bed. Many careful firemen, for exam- e, will partially close the ashpit dampers after firing, so at, if necessary, the flow of air through the door grids ill be increased. These two dampers should give per- ct control over the combustion, providing there is always fficient stack draft, and their proper handling should duce the amount of smoke and coal bills to a minimum.

For individual control and operation in a plant of two more boilers, each should be equipped with a draft- gulating damper. This will permit of pushing any oiler that might lag behind the others and in this way et the most out each individual boiler. Where there are itomatic nonreturn valves on each boiler, however, this rather difficult, because the damper will automatically en when the pressure goes down, and for the same rea- n the valve will close; thus they tend to oppose each her.

The usual procedure in such instances is to connect e damper regulator to the main steam line or to the ain header, which results in the loss of the individual oiler-control feature that would otherwise obtain and hich is always desirable.

Fairbanks Renewable Seat Valves

Although iron-body and brass-body gate valves have en put on the market for some time by the Fairbanks o., 416 Broome St., New York City, the renewable seat- ng feature is new.

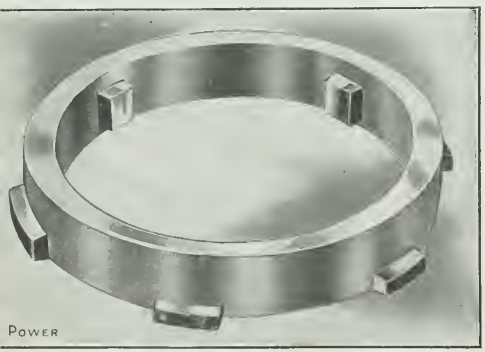


Fig. 1. Seat Ring for Removable Iron-Body Gate Valve

The renewable seat ring, Fig. 1, is made of bronze and held in the body casting by specially constructed cut hreads and lock in place similar to a gun breach block. The seats can be changed by the use of a wrench. The eat rings engage with the bronze face of a double-taper olid wedge, and pressure may be applied to either side f the valve.

A view of the renewable iron-body gate valve is shown n Fig. 2. The seat-ring feature permits of expansion nd contraction.

In Fig. 3 is shown a phantom view of the renewable-seat brass gate valve. The seat rings are separate pieces, engaging in a recess cut in the lower portion of the valve body and held in place by a saddle, machined to fit on the

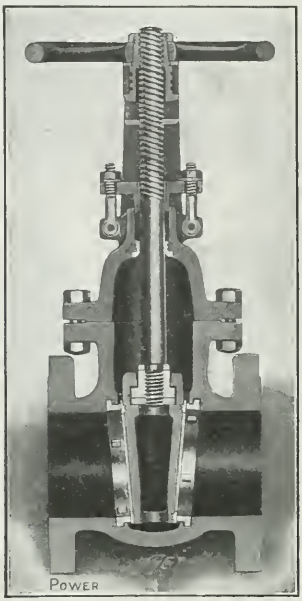


Fig. 2. Removable Ring in Iron-Body Gate Valve

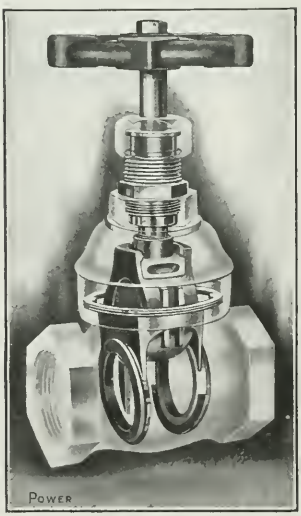


Fig. 3. Phantom View of Brass Gate Valve

upper surface of the rings; the saddle is held firmly to its position by a locking ring screwed into the body thread. Both types of valves are made in stationary and rising-spindle types.

ELECTRICAL DEPARTMENT

Transformer Characteristics—II

By Edward T. Moore

Efficiency

The efficiency is the ratio of the output to the output plus the losses, and if for each load the losses are known, the efficiency is easily determinable. The core losses which depend upon the density of magnetism are constant for a constant internal electromotive force, but, except for capacity loads, decrease to a negligible extent as the transformer is loaded. Hysteresis loss can be reduced only by decreasing either the density of magnetism or the volume of the core, both of which decreases soon reach a limit in any practical transformer. The loss due to the eddy currents varies as the square of the thickness of the laminations. These laminations are coated with "japan" or varnish, which serves to insulate the individual sheets sufficiently to prevent a cross-current between them. As the insulation and the normal coating of oxide require an appreciable portion of the total space when the laminations are very thin, the space area for active lines is reduced in a given cross-section, so that for a constant number of lines through the core, the actual magnetic density is increased by the presence of insulation when the laminations are subdivided. Modern practice has almost accepted 14 mils as standard thickness for transformer plates, for 60 cycles, while for 25 cycles thicker sheets are frequently employed.

For a given transformer the copper loss depends entirely upon the current in the primary and secondary coils. Since to transmit energy at a given rate requires a larger current when the power factor is low than when high, energy can be most efficiently transmitted by the transformers when the power factor is unity, or 100 per cent.

Assuming a constant internal electromotive force at all loads, the total transformer loss is made up of a constant loss and a loss varying as the square of the currents. With noninductive load, the increase of copper loss with load is almost independent of the exciting current which may be considered as producing merely an additional core loss at all loads. The efficiency will, therefore, be a maximum for that load at which the variable losses equal the constant losses. Transformers designed to operate continuously at full load usually have the point of maximum efficiency occur at that load. For many systems, the transformers must operate the larger part of the time on light loads and reach full or overload for only a relatively small time, for which service, the core loss is the determining element for the efficiency, while the copper loss is of relatively small moment. For other systems, the regulation is of prime importance, so that the copper loss is the determining element.

Temperature Rise

The loss in a transformer appears as heat in the windings and core, which must be dissipated as fast as generated in order to prevent excessive rise in temperature. In small transformers, the heat is dissipated sufficiently by radiation and convection in the surrounding air, but as the rating increases, the surface increases more slowly, so that large transformers if cooled by air alone would become much warmer than small ones. Therefore, it is necessary to supply some auxiliary cooling medium, and for this purpose, oil has been found well adapted, while its excellent insulating and puncture-repairing qualities render its adoption further desirable. When necessary, the oil is further cooled by the circulation of water in pipes immersed in the oil, or the oil is pumped from the transformer and cooled before being returned to it. Another common method of artificially cooling transformers is by means of a blast of air directed so that it will pass through ducts between the section of the core and the subdivision of the coils, and between the coils and core.

Since the specific heat of the air is 0.2375 and air weighs 0.0807 lb. per cu.ft., there is required 0.01915 B.t.u. to raise the temperature of 1 lb. of air 1 deg. F., or 0.0345 B.t.u. to change the temperature of 1 cu.ft. of air 1 deg. C. Since 1 kw. of power represents a transfer of 56.9 B.t.u. of energy per minute, each kilowatt of loss would require 1650 cu.ft. of air per minute to hold the temperature rise at 1 deg. C. Experience has shown that for most installations, a temperature rise of 15 deg. C. between the entering and leaving air is permissible. Therefore, in operating the air blast without the aid of direct radiation, there would be required for each kilowatt of loss, 110 cu.ft. of air per minute. It is customary, however, to allow 150 cu.ft. of cooling air per minute for each kilowatt loss. The required amount for any transformer can be easily calculated from the efficiencies. For instance, a 500-kv-a. transformer having a full-load efficiency of 98.2 per cent. would have a loss of 1.8 per cent., or 9 kw.; hence would require $9 \times 150 = 1350$ cu.ft. of air per min. In specifying a blower set for a group of transformers, it is advisable to calculate the amount of air required by the transformer at 125 per cent. load, and to add about 5 per cent. to this calculated amount to allow for leakage in the air chamber and passages. The pressure at which the air should be supplied to the transformers depends on the size, voltage and frequency, as the lengths and therefore the resistance of the ventilating ducts depend on these values; the pressure, however, will not ordinarily vary between the limits of ½ oz. and 1½ ounces.

For water-cooled transformers, the cooling pipes are made without any seam or joint within the tank, and they are kept wholly below the upper surface of the oil in the tank. The tubing is usually from 1 to 2 in. in diameter, the length depending upon the amount of heat to be carried away and the difference in temperature between the oil and the water. The cooling surface of the pipes required will depend also upon the amount of heat which

external surface of the core will dissipate, but it may tated that the surface of the pipes in contact with oil varies from 0.5 to 1.3 sq.in. per watt of total trans- ner loss. The amount of water required depends on difference in temperature of the incoming and out- g water. Each kilowatt-minute of energy to be car- away represents 56.9 B.t.u., or 56.9 lb. of water ed in temperature 1 deg. F. For a temperature rise 4 deg. C. in the water, there would be required 1.32 f water per minute per kilowatt of loss. Estimating weight of water as 8.30 lb. per gal., each kilowatt of would require each minute 0.158 gal. of water ged in temperature 24 deg. C. For instance, a 500- n. transformer having a full-load efficiency of 98.2 cent. would have a loss of 1.8 per cent., or 9 kw., and would require $9 \times 0.158 = 1.42$ gal. of water per ute.

ransformers cooled by forced-oil circulation are used large extent for large units above, say, 1000 kv.-a. heated oil is pumped from the top of the transformer the cooled oil is forced to enter the ducts in the sformer windings and core at the bottom. For the pose of directing the course of the cold oil, the lower of the transformer is inclosed and the only outlet for oil is upward through the ducts. The rate of circula- is limited solely by the ability of the pump to move oil. The saving in cost of the complete transformer pment when forced-oil circulation is substituted for ed-water circulation may be as high as 25 per cent. 10,000 kv.-a. units, but it practically disappears for s as small as 1000 kv.-a.

Regulation

egulation is the percentage increase in the secondary age of the transformer as the load is decreased from normal value to zero, the primary voltage being held tant at the normal value. It is usual to assume in ing a test that a transformer will be operated at a y power factor. Such, however, is not always the and to cover all conditions, it should be noted that losses depend upon the volt-amperes, quite independ- of the power factor. Thus, at 75 per cent. power or the losses are the same at 75 per cent. load as they ld have been at 100 per cent. load for 100 per cent. er factor. Moreover, the regulation depends very ely upon the power factor; it is much worse at 75 cent. load and 75 per cent. power factor than it is at per cent. power factor and 100 per cent. load. There- , in making a full-load test of a transformer, it is de- ble, and in many cases necessary, to duplicate the ial conditions under which the transformer is to op- e.

Frequency

ny 60-cycle transformer can be operated at a higher quency and at the same voltage with a slight decrease he iron loss and a corresponding improvement in the iency. The relative change in the iron loss of a trans- ner as the frequency is varied is shown by the curve Fig. 8.

Although for a constant impressed electromotive force, iron loss increases as the frequency is lowered, it is sible to operate any 60-cycle transformer at a much er frequency without any increase in iron loss by de- asing the voltage slightly. With constant impressed electromotive force, the eddy-current loss is independent of the frequency, while the hysteresis loss varies inversely as the 0.6 power of the frequency. At constant frequency, the hysteresis loss varies as the 1.6 power and the eddy-current loss as the second power of the electromotive force.

Neglecting the change in eddy-current loss with a change in the voltage, the voltage for constant iron loss varies as the three-eighths power of the frequency. That is, if when the frequency is doubled the voltage is increased by 29.7 per cent., the iron loss is not altered and the hysteresis loss is the same, but the eddy-current loss increases by 29.7 per cent. Likewise, when the frequency is lowered by 50 per cent. the electromotive force is decreased by 22.9 per cent. the iron loss is unchanged and the hysteresis loss is the same, but the eddy-current loss is decreased by 22.9 per cent. Thus, a 2200-volt, 60-cycle transformer can be operated at about 2850 volts at 120 cycles, or at about 1700 volts at 30 cycles, without any appreciable change in the iron loss. It is to be noted, however, that the transformer must be provided with additional high-tension taps for these percentages above and below normal voltage, as standard transformers are generally supplied only with high-tension taps for approximately 3, 6 and 9 per cent. below normal operating voltage.

A 25-cycle transformer operating on a 60-cycle circuit will have its regulation impaired somewhat and if the load is composed of induction motors, their torque will be reduced. This difficulty, however, is not so serious

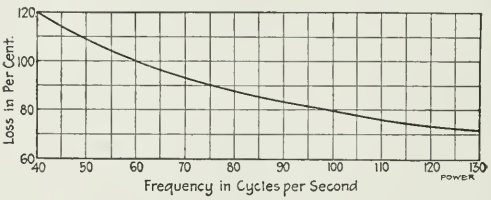


Fig. 8. Variation of Iron Loss with Frequency

with a synchronous motor load as power-factor conditions are much higher. For example, assume a 375-kv.-a., 25-cycle transformer operating on a 60-cycle circuit of 80 per cent. power factor, the regulation would be approximately 5.5 per cent. instead of 2.8 per cent. were it operating on a 25-cycle circuit. With a synchronous motor load and 100 per cent. power factor, these transformers operating on 25 cycles would have a regulation of 1.05 per cent. and 1.5 per cent. on a 60-cycle circuit. This poorer regulation could be compensated for by making use of a high-tension tap to raise the low-tension voltage by 5 per cent.

Insulation Tests

Insulation tests are made according to the following table which is based on the "Standardization Rules of the American Institute of Electrical Engineers":

Rated Terminal Voltage of Circuit	Test Voltage
Not exceeding 549 volts	5000
Exceeding 549 but not exceeding 5000 volts	10,000
Exceeding 5000 volts	Double rated terminal voltage of the circuit

The rated terminal voltage of the circuit is the voltage between the conductors of the circuit to which the transformer is connected. From this it follows that where

single-phase transformers are to be connected in star on a three-phase circuit, the line voltage and not the transformer voltage determines the test voltage. An exception may be made to this in case the neutral point is to be connected directly and permanently to the ground. The transformer voltage (the voltage from the neutral point to the line) may then be considered as determining the test voltage. The test between the high- and low-tension windings is the same as that between the high-tension winding and the core, and both tests are made simultaneously with the low-tension winding connected to the core. The duration of the test is one minute. A test is then made between the low-tension winding and the iron for one minute. In addition to these tests, 200 per cent. of normal voltage is impressed on the low-tension winding for 5 min., with the high-tension winding not connected to either the low-tension winding or the core. This test induces double normal voltage throughout the windings and thereby subjects every part to double the normal stresses.

New Insulating Material

A new material known as "Micarta," to take the place of hard fiber, glass, porcelain, hard rubber, built-up mica, pressboard, rawhide, molded compounds, etc., has been developed by the Westinghouse Electric & Manufacturing Co. It is used for commutator bushings and brushholder insulation, as noiseless gear blanks, as conduit for automobile wiring, as spools for spark coil and magnet windings, for refillable fuse tubes, for wireless coil separators, for arc shields in circuit-breakers, for watermeter disks, etc.

It is a tan-brown, hard, homogeneous material having a mechanical strength about 50 per cent. greater than hard fiber, and can readily be sawed, milled, turned, tapped or threaded, if a sharp-pointed tool is used and the work is done on a lathe. It can be punched only in thin sheets and cannot be molded. Micarta is not brittle and will not warp, expand, or shrink with age or exposure to the weather, but takes a high polish, presenting a finished appearance.

Two grades of the material are made. The grade known as "Bakelite" Micarta will stand a temperature of 300 deg. F., continuously, or 500 deg. for a short time. It is infusible and will remain unaffected by heat until a temperature sufficient to carbonize it is reached. Heat will not warp Bakelite Micarta, and it will stand an electric arc better than hard fiber, hard rubber, built-up mica, or any molded insulation containing fibrous or resinous materials. Its coefficient of expansion is low, being approximately 0.00002 per deg. C.

Bakelite Micarta is insoluble in practically all of the ordinary solvents, such as alcohol, benzine, turpentine and weak solutions of acids and alkalis, hot water and oils. It is indifferent to ozone—an advantage over hard rubber, resins, etc., for electrical purposes. It is nonhydroscopic and impervious to moisture.

The other grade designated as No. 53 Micarta has the same mechanical and electrical properties as the Bakelite Micarta, but differs in its chemical and thermal properties. It behaves toward chemicals and heat very much as an ordinary resin. This grade is not used in plate form.

CORRESPONDENCE

Hunting of Generators

In answer to A. N. Kerr's request for information as to the probable cause of his generators hunting when running in parallel, I would state that it might be due to one or two causes out of several. It is well to remember that when two or more alternating-current generators are run in parallel, that the division of the load between them depends primarily upon their speed-load characteristics. Therefore, it is essential that the two Harting governors act freely and equally sensitive for the same relative loads, so that the tendency would be to divide the load properly when operated in parallel.

Mr. Kerr does not state how the exciters are connected—individually or in parallel—at the switchboard. If the exciters are for individual operation only, I would suggest that an e.m.f. chart be taken for both exciters, from similar current readings. If everything else is all right, such as both belts being in perfect running condition, commutators and brushes smooth and properly set, and the speed equal, then the e.m.f. curve should keep the same for both machines. If it does not, the compound winding on the exciter having the higher e.m.f. should be shunted to balance with the lower characteristics of the other exciter.

If the power factor is low, or the load variable, then the use of a small synchronous motor connected to the main busbar would be an aid to improving the power factor.

Regulators are a great help in maintaining the exciter voltage in proper relation to the generator load. This is especially true when load variations are great and frequent.

BEN DAWSON.

Cedar Rapids, Iowa.

I have the following to suggest in regard to A. N. Kerr's trouble with hunting (see POWER, Sept. 2, 1913).

He should first ascertain the speed of each machine by the formula

$$R.p.m. = \frac{120 \times frequency}{number\ of\ poles}$$

Having done this he should adjust the governor on the small engine sensitive and that on the large engine sluggish; or it may be necessary to make both governors somewhat sluggish if the machines do not remain in step with one governor sensitive and the other sluggish.

If surging still continues, make the admission earlier on the small engine on one end only (the head end is preferable) or the compression may be reduced on the head end of the large engine.

The foregoing have proved successful in overcoming hunting in our plant.

V. K. STANLEY.

Ponca City, Okla.

Electricity Cheap in Switzerland—Cheap power, widely distributed in Switzerland, has led to the introduction of small motors mounted wheelbarrow-wise for farm and similar uses. A complete installation of a 1-hp. motor, starting box, speed-change gears and pulley, barrow mounted with 10 meters (about 33 ft.) of cable, costs about $90.

GAS POWER DEPARTMENT

The First Diesel Locomotive

The first locomotive to be propelled by a Diesel engine as designed and built at the works of Messrs. Sulzer ros., in Winterthur, Switzerland, and delivered by them me months ago to the Prussian-Hessian State Railway f Germany. We are indebted to the builders for the accompanying description and drawings together with hotographs of the complete locomotive as it appears in ervice.

Fig. 1. Side View of Sulzer-Diesel Locomotive

In substance the basic idea is a propelling engine dect-connected to the axles of the driving wheels and, independent of it, a complete auxiliary engine of about ne-fourth the capacity, serving for the production of ompressed air with which the main engine is started and hich, with late cutoffs, is also supplied to it under cerain running conditions, as ascending steep grades, etc. hat the service rendered by the auxiliary engine may e at times increased, air reservoirs are provided from hich, with the auxiliary at rest or in operation, a furher supply of air can be taken.

While starting, the auxiliary engine is kept running, ms uninterruptedly furnishing a relatively large flow f compressed air for setting the main engine in motion; dding to it from the air reservoirs as may be needed. y means of the compressed air alone the train is aelerated to a speed of five or six miles per hour. The uel is then admitted, the air cutoff and the engine oprated on the normal Diesel cycle.

The locomotive has a length of 54.4 ft. and weighs in ervice 95 tons. The two trucks have a wheel base of 7.2 t. and the rigid wheel base is 11.8 ft. From center to center of the truck center pins measures 32.8 ft., and the driving wheels have a diameter of about 69 in.

The motive effort is transmitted from a crankshaft to the driving wheels by means of side rods, the ends fitted with adjustable boxes.

A Westinghouse brake equipment is included and applied to both the driving and the truck wheels and in addition a toggle-joint hand brake is provided for the former. The air for braking is taken from the intermediate stage of the compressor and is stored in a special reservoir, and pneumatic sanding appliances are provided for use in either running direction.

For the protection of the equipment the cab is continuous over the full length of the locomotive. In each corner is a tank, three for cooling water and one for fuel storage, and in the roof, over the main engine, is the exhaust muffler. Two coolers for the circulating water are provided as are also two pumps driven either by the main or by the auxiliary engine, one for circulating the cooling water and the other for supplying the fuel.

The motive power is furnished by a Sulzer-Diesel, reversible, four-cylinder, single-acting, two-stroke-cycle engine. The cylinders are arranged in pairs, each inclined 45 deg. from a line perpendicular to the rail surface, their axes intersecting in that of the single crankshaft common to all; they have a bore of 15 in. and a stroke of 21.65 in. Each pair of opposed cylinders lies in a common plane and acts on a common crankpin and that such action may be entirely symmetrical the crankpin end of one of the opposed connecting-rods is forked. The two cranks are set at 180 deg. and at 60 miles an hour make slightly over 300 r.p.m. Pressed in place on each

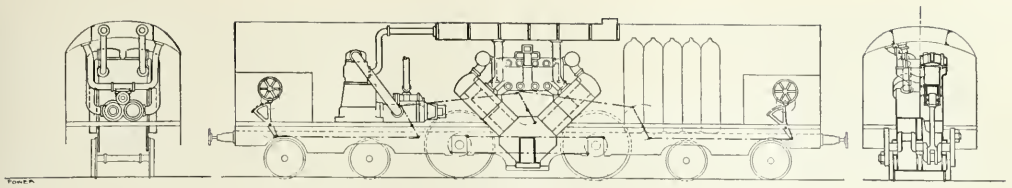


Fig. 2. Showing Arrangement of Engines and Auxiliaries

end of the crankshaft is a counterbalanced crank disk transmitting its rotation to the driving wheels. By this arrangement a complete balance is obtained between the primary forces of reciprocation emanating from the main cylinders, and the centrifugal forces of the cranks, side rods and counterweights.

Each cylinder head carries a fuel valve, a starting valve and two scavenging valves, admitting air under 700 to 1000 lb., 700 and 20 lb. respectively. The exhaust is through ports in the cylinder walls, opened and closed

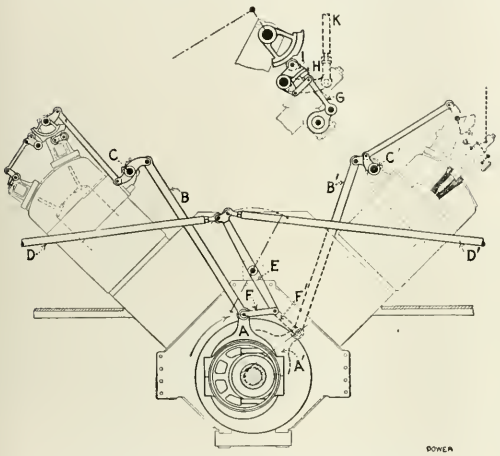


Fig. 3. Showing Eccentrics and Links for Actuating Valves

by the main pistons. Between the crank disks and the frame are two eccentrics of which each one controls all the valves of one-half of the main engine and is rotatable for reversing the running direction, which is accomplished through a special linkage system, *DEF*, Figs. 3 and 4. The position of the lever *E*, represented by the solid lines, corresponds with forward running, that by dot-and-dash lines with reverse. By means of the rods *B* and *B'*, the motion of the two eccentrics is transmitted to the rockshafts *C* and *C''*, which actuate the valves in the cylinder heads. On the right-hand cylinder of Fig. 3 the gear for the fuel-admission valve is indicated; on the left-hand cylinder that for the scavenging valves. The control of the fuel-inlet valves is such that different admission volumes can be had, effected by varying the position of the free end of the rod *G* along the sliding contact surface *H* of the roller arm *I* by means of the reach rod *K*, thus governing the open position of the fuel-inlet valve.

The starting valves are operated in like manner as shown in Fig. 4. The open period of these valves must naturally be greater than that of the fuel-inlet valves, the period being determined by rotating the shaft *H* on which the bell crank *O*, Fig. 4, is eccentrically journaled. Placed in the starting pipe *K*, just ahead of the starting valve in the cylinder head, is another valve *L* which, as to its time and travel, is unvaryingly actuated by a cam secured to a vertical shaft driven through miter gears by the side rod *M* and controlled by the connection *R*. The provision of two controls for the starting air accomplishes the possibility of constant lead and the lowering of losses by throttling effect. With but one starting valve per cylinder it would be difficult to so arrange the

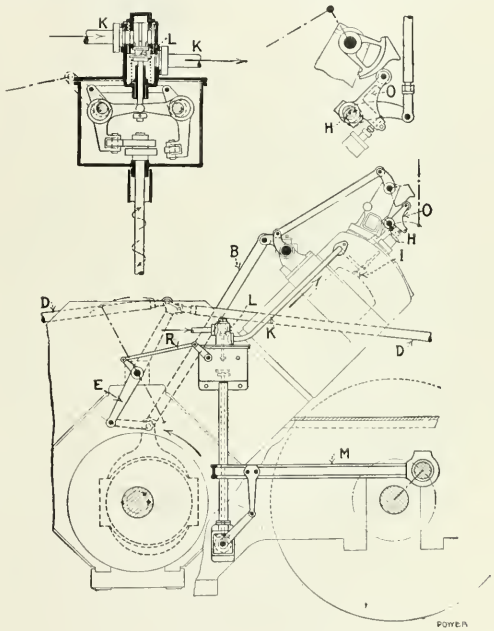


Fig. 4. Starting Valve-Gear

valve-gear that constant lead would result throughout the range of cutoff, in this case from 0 to 60 per cent. Further, the wire-drawing resulting from the unavoidable failure to obtain a quick opening and closing of the main starting valve would introduce important losses. The duplex gearing described eliminates these disadvantages.

Fig. 6 is a diagram of the coincident opening, lifting and closed positions of the two valves controlling the admission of the air for starting throughout a revolution

of the main crank; *AB*, indicating the curve of successive positions of lift of the initial valve *L*, and *CD*, those of the starting valve proper, *I*, for maximum, reduced and minimum cutoffs by that valve.

It is characteristic of this valve-gear that the curves *CD* of the main valve are symmetrical each side of the line *PP'*, radial to the crank circle. From this it is seen, on the one hand, that for all cutoffs the main valve is wide open at the dead-center position of the crank: hence

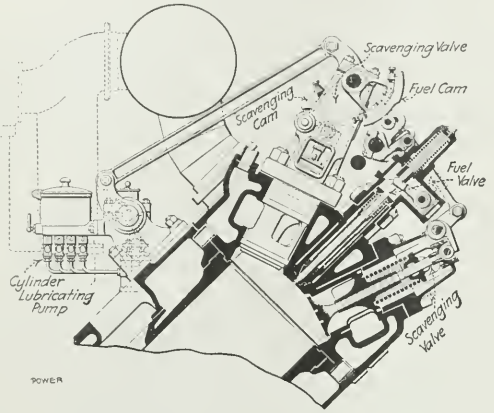


FIG. 5. VALVE DETAILS

the initial air admission is determined by the valve *L*; and, on the other hand, by using such gearing, reversal of the main valve is unnecessary and a change in the running direction is secured by reversing the action of the primary valve *L*.

Between the four main engine cylinders are the double-acting piston pumps and a three-stage air-injection pump for spraying in the fuel. All three pumps are driven from the connecting-rods of the front pair of main engines through the medium of rocker-arms and links and all are fitted with relief valves. The air-injection pump is in the nature of a reserve for the main compressor as, in the event of the latter being incapacitated through any cause, it is capable of supplying the injection air under conditions of normal speed and not too high a duty.

The auxiliary engine is likewise a two-stroke-cycle machine of 250 hp. It has two vertical cylinders 12 in. in diameter and 15-in. stroke, fed by a duplex fuel pump. The crankshaft has two counterbalancing flywheels, and two cranks 180 deg. apart and these latter, through other connecting-rods, actuate two horizontal, multi-stage air pumps; see Fig. 7. By means of a distributing valve the delivery of the compressor can be regulated from zero to maximum, and a governor controls the speed of the compressor engine between 200 and 350 r.p.m.

With the locomotive stopped or under service requiring but little air the compressor delivers its surplus output into receivers placed behind the main engine.

The air as delivered from each stage of the compressor is diverted through a cooler. From the high-pressure cooler the air is conducted to a distributor whence by valves it is led to various points as desired: one connection leading to the starting-air reservoirs, another to those for the injection air, and a third to the reserve reservoirs. These latter, through the distributer, are in turn in communication with the auxiliary engine, as are also the fuel-injection air reservoirs, for the purposes, respectively, of setting it in motion and maintaining it in operation.

For lubrication special pumps are provided. The amount can be regulated for each cylinder, and all crankshafts and connecting-rod boxes and all needed points within the crank cases are provided with forced lubrication; the oil being drawn from the crank cases, filtered and forced through piping to the required places.

Hand-operated centrifugal pumps are included for priming the cold water, circulating water and fuel piping when needed. A fourth pump is for lubricating inside the crank case when the locomotive is at rest.

An operating room is provided at each end of the housing for the engineman where are located the various actuating mechanisms, such as the lever for throwing into and out of action the starting and fuel valves,

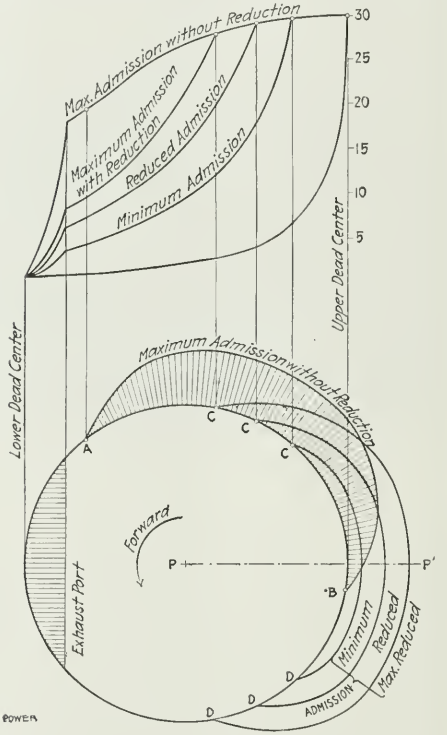


FIG. 6. DIAGRAM OF EVENTS DURING STARTING

the lever for regulating the deliveries of the fuel pumps, the starting monitor, the brake valve, the sander, the whistle connection and the various gages.

The starting preliminaries include the setting in motion of the auxiliary plant and the throwing in of the valve for the air used in starting the main engine. To get under way the air valve at the monitor is slowly opened. The air flows from the proper air reservoirs to the starting valves of the main engine, the air pressure

slowly rises and the engine begins to turn. The cutoff by the starting valve is gradually shortened, the pressure meanwhile rising. On attaining a speed of about six miles an hour the starting valves are cut out and the fuel valves brought into action. The locomotive is then in normal operation and the delivery of the pumps and the pressure of the injection air are regulated according to the service of the locomotive and its desired speed. To stop, the fuel valves are released from action and the brake is applied. Reversal is effected by the manipulation of a handwheel located in each operating room; a special stop preventing this while the fuel valves are cut in.

Trial trips were run with a view to observing the Diesel engine as applied to locomotive use and to note the action of starting and of the change from running by air to that of running as normally intended, and to test the reversing mechanism.

In Fig. 8 are shown reproductions of indicator diagrams taken during the runs.

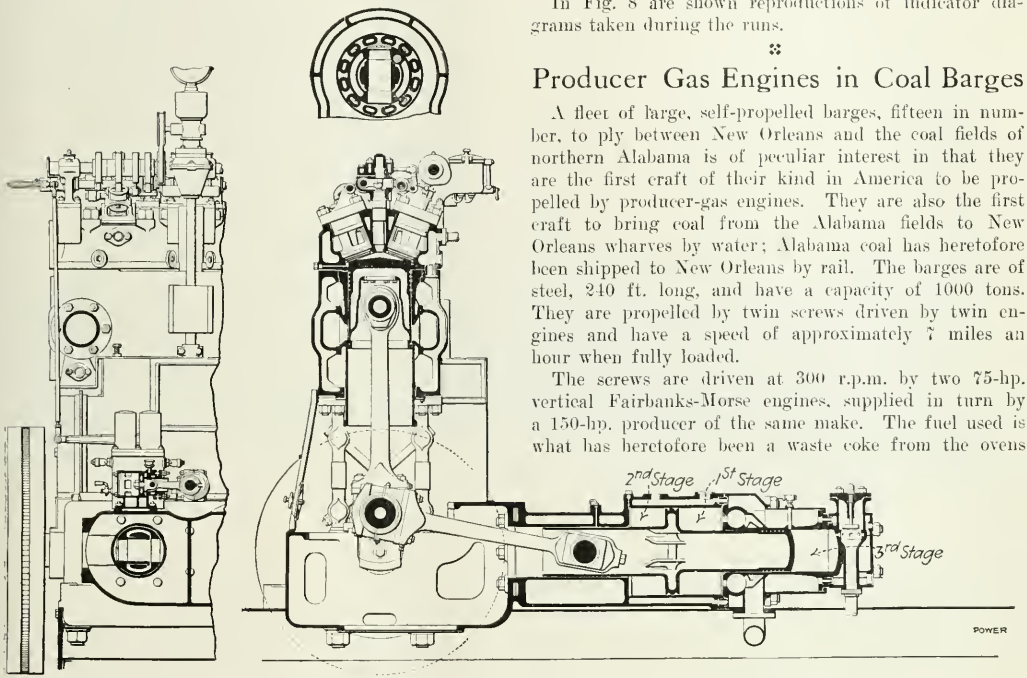


Fig. 7. Elevation and Section through Auxiliary Engine and Air Compressor

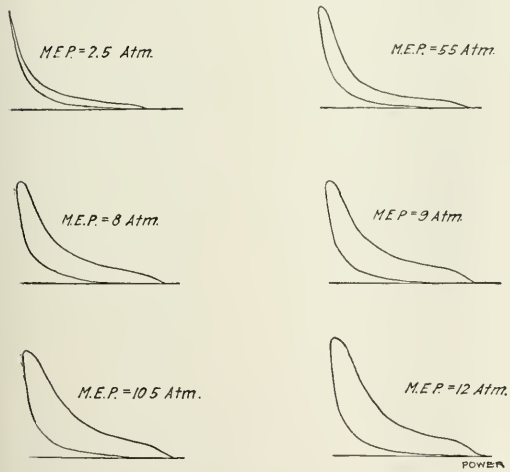


Fig. 8. Typical Indicator Diagrams

Producer Gas Engines in Coal Barges

A fleet of large, self-propelled barges, fifteen in number, to ply between New Orleans and the coal fields of northern Alabama is of peculiar interest in that they are the first craft of their kind in America to be propelled by producer-gas engines. They are also the first craft to bring coal from the Alabama fields to New Orleans wharves by water; Alabama coal has heretofore been shipped to New Orleans by rail. The barges are of steel, 240 ft. long, and have a capacity of 1000 tons. They are propelled by twin screws driven by twin engines and have a speed of approximately 7 miles an hour when fully loaded.

The screws are driven at 300 r.p.m. by two 75-hp. vertical Fairbanks-Morse engines, supplied in turn by a 150-hp. producer of the same make. The fuel used is what has heretofore been a waste coke from the ovens of the Birmingham District, and which consequently is secured at a very low price. This coke is practically pea size, and has a calorific value of about 11,000 B.t.u. Bunkers are provided to hold about 15 tons. Each producer is equipped with a scrubber, gas tank and tar extractor, and is fitted with a water bottom.

The auxiliary power equipment consists of a 9-hp. gasoline engine, which drives a centrifugal pump handling the ballast and bilge water, a blower, an air compressor and a 5½ kw. direct-current generator. Current is used for electric lights throughout the boat, fans in cabins and engine room, a 3200-cp. searchlight and a 5-hp. motor. The motor is for operating an anchor winch. The generator is so mounted that when the large engines are running it may be belt driven from one of them. A second 4-in. centrifugal pump is also installed, to be driven by one of the large engines through friction-wheel contact.

The barges will make the trip from the mine region to New Orleans in 72 hr., and with all fifteen vessels in service it is estimated that coal will be moved into New Orleans at the rate of 50,000 tons a month.

REFRIGERATION DEPARTMENT

Ammonia Condensers—II

By Fred. Ophüls

Double-Pipe Condensers

The condensers illustrated in Figs. 3 and 4* are not of the purely counter-current type for the reason that the flow of the ammonia through the condenser coils is perpendicular to the flow of the water over the outside. The requirements of counter-current flow are not only that the hot ammonia vapor is cooled by the water near the point where it leaves the condenser and that the liquid ammonia leaves at or near the point where the water comes on the condenser, but also that the current of ammonia flows parallel to the current of water and in opposite direction to it. While these types fulfill the first requirement they do not meet the latter. There is, however, an ammonia condenser built that is designed to meet both conditions; this is the double-pipe condenser.

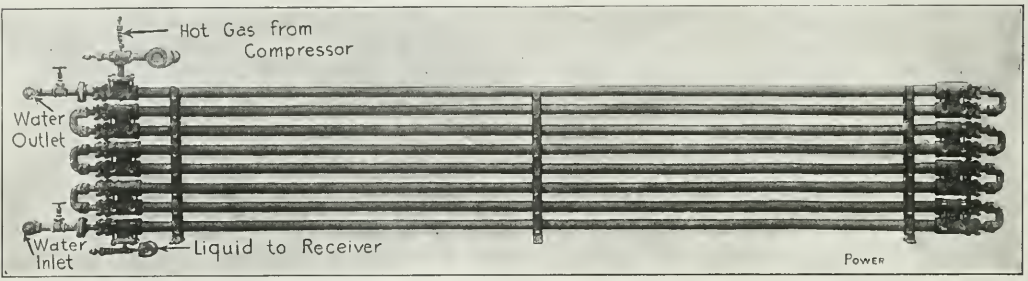


Fig. 7. Double-Pipe Ammonia Condenser

Figs. 7 and 8 show that the basis of construction of type (a) is the placing of a smaller pipe inside of a larger one. The condenser is generally made up of 1¼-in. and 2-in. pipes; the former pass through the latter and are fitted at their ends with return bends to afford a continuous passage for the water through them either from the bottom to the top pipe or vice versa. The 2-in. pipes, cut shorter than the 1¼-in. pipes, are also joined by return bends through the ends of which the 1¼ in. pipes pass, and the ammonia vapor is cooled and liquified in the annular space between the inside of the larger and the outside of the smaller pipes. In this design the ammonia is made to flow parallel and in opposite direction to the water, for the ammonia enters the annular space at the free end of the top pipe and the water enters the inside of the 1¼-in. pipe at the free end of the bottom pipe or vice versa.

In type (b) a double-size condenser is arranged with the water header and the ammonia-vapor and liquid header located at opposite ends of the condenser. The objection to this arrangement is that in alternate pipes the water and the ammonia flow in the same direction.

*See Sept. 2 issue, page 335.

Surface Condensers

For some time attempts have been made to imitate the standard construction of the surface steam condenser, but great difficulty was experienced in so designing this type for ammonia work as to prevent leakage of ammonia into the water. The main difficulty was found in keeping tight the joints between the straight tubes and the tube sheets on account of the variations in expansion and contraction.

The first successful design of what may be called a surface condenser for ammonia was constructed with spiral coils (type a) through which the cooling and condensing water flowed. Figs. 9 and 10 illustrate this type. It consists of a cast-iron or steel shell closed at both ends by dished heads. Within this shell are placed a number of closely wound spiral pipe coils, the top and bottom ends of which protrude through the respective heads and are each joined by means of manifolds. Where the ends of the pipe coils pass through the heads tight joints are made with the usual packed stuffing-boxes and glands.

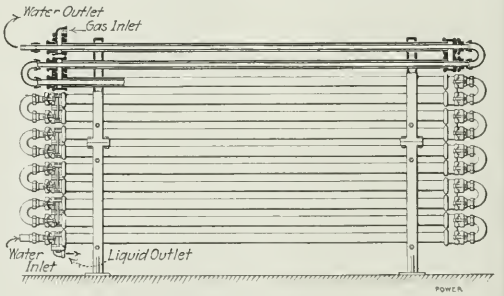


Fig. 8. Construction of the Double-Pipe Condenser

The ammonia vapor surrounds the pipe coils and enters near the top of the shell as shown. The liquid is drained off either at the bottom of the shell or else at the side of the lower head. The water enters the bottom coil

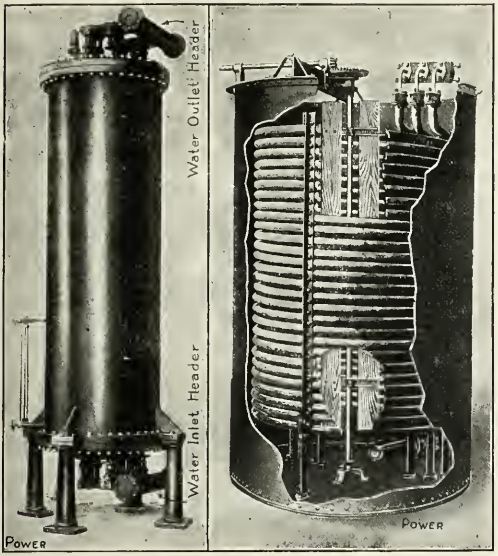


Fig. 9 Fig. 13

FIG. 9. SPIRAL-COIL TYPE SURFACE CONDENSER

FIG. 13. SUBMERGED CONDENSER WITH MECHANICAL WATER STIRRER

manifold and flows up through the pipe coils, leaving at the top. The flow of the vapor is perpendicular to the flow of the water, but the general direction of flow is opposite.

From the illustration, Fig. 11, of a straight-tube type of surface condenser, it appears that its construction is very similar to the standard surface steam condenser. The sketch is not intended to represent a particular design, but to give an idea of the general way in which such a condenser is arranged. The cooling and condensing water enters at the bottom of half the tubes and flows to the opposite head, returning through the remaining tubes to the bottom. The head where the cooling and condensing water enters and leaves is divided by a partition so that the incoming and outgoing water does not mix. In some designs a partition is used in the vapor space to cause a flow counter-current to that of the water, but in the case illustrated the partition is not used. The ammonia vapor enters at the top, and the liquid leaves at the bottom on the opposite side.

SUBMERGED CONDENSERS

When refrigerating and ice-making machines were first built the submerged condenser was used in almost all cases. These condensers are cheap in first cost and readily constructed. They do not give results which can be compared favorably with most of the other types.

Figs. 12 and 13 show the construction of submerged condensers with spiral coils. The ammonia flows through the coils, generally entering at the top, and the cooling and condensing water circulates in the surrounding tank. The arrangement of the vapor and liquid headers varies somewhat with the taste of the designer.

In some of the constructions the liquid is drained off at the bottom directly into the liquid receiver, as shown in Fig. 12. Sometimes the bottom ends of the coils are turned up inside the tank and the liquid headers located near the vapor header just outside of the tank, Fig. 13. The cooling and condensing water enters the tank at or near the bottom and leaves at the top, the inlet and outlet water connections being located at opposite sides of the tank.

On account of the poor circulation of the water the heat transmission coefficient of the cooling-pipe surface is low and the capacity of a certain size condenser is small in comparison to an atmospheric condenser contain-

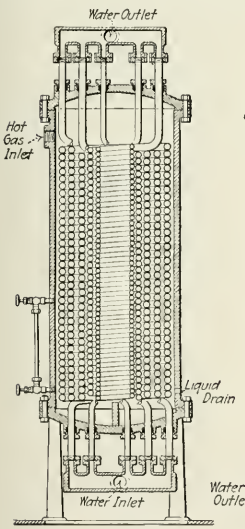


Fig. 10

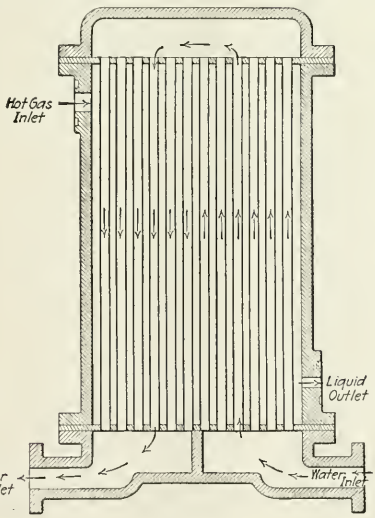


Fig. 11

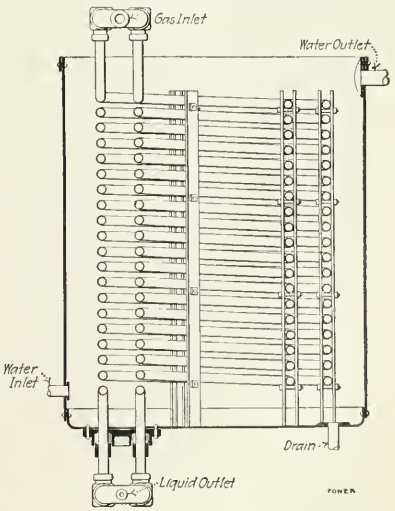


Fig. 12

FIG. 10. SECTIONAL VIEW, SHOWING ARRANGEMENT OF THE SPIRAL-COIL SURFACE TYPE. FIG. 11. STRAIGHT-TUBE SURFACE CONDENSER. FIG. 12. SPIRAL-COIL SUBMERGED CONDENSER

ing approximately the same area of condensing surface. To improve the efficiency of these condensers some have been designed with mechanical stirrers which consist of a number of paddles rotating about a vertical shaft placed in the center of the tank, as in Fig. 13. The paddles circulate the water in opposite direction to the flow of the ammonia through the coils. Sometimes the paddle blades are inclined at a slight angle to the vertical to give to the water an upward motion.

The straight-coil type illustrated in Fig. 14 consists of one or more vertical pipe stands made up of horizontal pipes either bent to close centers or else joined by means of return bends to afford a continuous passage for the ammonia through them. These coils are submerged in a

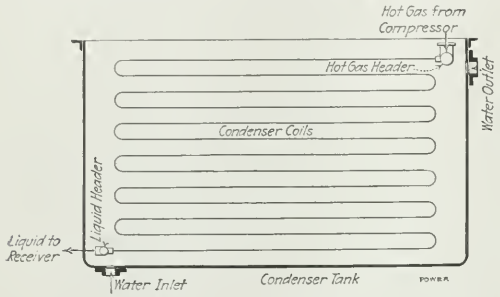


FIG. 14. STRAIGHT-COIL SUBMERGED CONDENSER

suitable rectangular tank and the vapor and liquid headers arranged somewhat as shown. The cooling water enters near the bottom of the tank at the end where the liquid ammonia leaves, and is drained off at the top of the other end, where the hot vapor enters. The disadvantage of this construction is that the cooling water has a tendency to short-circuit diagonally across the tank from the point where it enters to where it leaves, so that there are parts of the tank in which the water does not circulate properly.

Removing Ammonia Charge from Compression System

To remove the old charge of ammonia from the system, attach to the charging valve a standard ammonia drum on a platform scale by means of a ½-in. pipe about 10 ft. long. The drum should be so connected that the pipe nipple within the tank is turned up.

It is essential not to charge into a standard 100-lb. liquid drum more than 100 lb., and, for this reason, the drum should be placed on the scale and the weight noted from time to time while drawing off the ammonia. It is, of course, necessary to close the main liquid valve going to the ice-making or refrigerating system, so that the ammonia which is discharged from the condenser into the receiver can pass directly into the drum.

When it is not certain that the drum receiving the charge of ammonia is empty, and the net weight of the drum is not known, it may be assumed that the 100-lb. drum, when empty, does not weigh more than 200 lb., so that when it is fully charged the scale should show not to exceed 300 lb.

In drawing off the charge of ammonia, the system is operated just as if pumping out the low-pressure side of the plant, and if there is no liquid-level gage on the receiver, the only way to tell when the system is empty of liquid is to find out when the drum on the scale shows no further increase in weight.

Care should be exercised to make sure that the expansion side of the plant is fully pumped out before starting to break any joints, and depending upon the size of the plant and its arrangement, it may be necessary to pump below atmospheric pressure five or six times, before the ammonia is all drawn out. When this has been done, allow the system to stand for two or three hours and see whether the pressure on the suction gage does not rise. If it does not, the system is empty.

While drawing off the charge of ammonia it would be advisable to reduce the amount of water flowing over the ammonia condenser, so that the discharge pressure will be high enough to force the liquid into the drum. By referring to a table giving the properties of ammonia corresponding pressures and temperatures may be obtained. For example, suppose that the room in which the charging valve is located is at 95 deg., F., at the time the charge of ammonia is being removed from the system. The ammonia pressure corresponding to this temperature would be 184 lb. gage, so that the ammonia may freely flow into the drum. The condenser pressure should be at least 10 lb. higher than this pressure.

The principal things to look out for, then, are to see that not too much ammonia is charged into the drum and that the condenser pressure is at least 10 lb. higher than the pressure corresponding to the temperature of the room in which the drum is located. The ammonia vapor left in the high-pressure side of the plant, after the liquid is drawn off, cannot be recovered. It must either be blown out, or else pumped over into the low-pressure side after the latter has been repaired.

Turbine Exhaust for Ice Making

The engine room of the new power plant of the Kentucky Traction & Terminal Co., at Lexington, has an ice plant quite different from those ordinarily met. Two 75-hp. Terry turbines, direct connected to two 8000-gal. centrifugal water pumps for pumping cooling water from the spray pond for the steam and ammonia condensers, furnish exhaust steam for a Corbondale ice plant.

The liquid ammonia from the condenser passes through a 1½-in. pipe line a distance of more than 500 ft. to the building containing the ice tanks, where it is expanded through the coils. The expanded vapor from the expansion coils, after passing through the coils in the distilled-water storage tanks, returns through a 6-in. line to the absorber on the roof of the power house.

The exhaust from one of the turbines is sufficient for the generator under ordinary circumstances. During the summer months, with condensing water at 95 deg. F., the increased steam consumption due to back pressure on the turbine does not exceed 20 lb. per hr. per ton of ice—about one-third that required for a compound condensing compression machine. During the winter months the excess consumption is but three pounds per hour per ton of ice. As the condensate from the turbines is free from oil, the ice is of excellent quality. The plant was erected under the supervision of Sargent & Lundy, consulting engineers, of Chicago.

EDITORIALS

The Diesel Locomotive

After several years of experimentation, during which many obstacles were encountered and overcome, a Diesel locomotive has been completed and put in service.

Referring to the description on page 470, one is first impressed with the apparent complexity of the arrangement as compared with the familiar steam locomotive. Flexibility of operation has, of course, been one of the big problems in working out the design, and this has been obtained only by the employment of an auxiliary plant of about one-fourth the capacity of the main engines, for starting and accelerating up to a speed of five or six miles per hour. This has added greatly to the weight per horsepower.

Conceding that this is a first attempt and that time will undoubtedly bring improvements with corresponding simplification, still it is doubtful if the Diesel will ever attain that degree of flexibility possible with the steam locomotive.

The gasoline engine has reached as high a stage of development in its line as the Diesel engine, yet it has proved unsuitable for driving interurban cars direct; hence the gasoline-electric drive was resorted to and has given excellent satisfaction on many roads. It would seem that the field for the Diesel engine for locomotion might lie along similar lines.

Figures are not available at this time as to the economic performance of this locomotive, and until they can be compared with those of a steam locomotive running under similar conditions, the commercial value of the former must remain an unknown factor.

Standard Pipe Flanges

The committees of the several engineering societies responsible for the 1912 United States Standard for Pipe Flanges and the manufacturers who took exceptions thereto and produced the Manufacturers' Standard, have gotten together and effected a compromise. While this compromise standard is not so good as could have been made, starting with a clear field, it is probably the best which could be done under the existing circumstances, taking into account the interests of the manufacturers and the protection of their large investment in patterns and stock of the prevailing dimensions.

The compromise was effected by the adoption by the manufacturers of the number of bolts, diameter of bolt circle and thickness of flange advocated by the committees, retaining, however, their own face-to-face and face-to-center dimensions, except as they were modified to meet the other changes. This brings about the desired uniformity in the flanges themselves, and sacrifices only the interchangeability which the 1912 U. S. Standard sought, in prescribing the same face-to-face and face-to-center dimension for fittings for similar sizes of pipe. This feature was of less practical importance than it appeared, and upon the comparatively rare occasions in which fittings in a pipe line are removed to be replaced by others of the same size, as a cross for a tee, the user can better afford to pay the slight charge for a special fitting than the whole trade to go through the convulsion of getting them all alike.

We are glad to see the matter amicably settled. Manufacturers representing 85 per cent. of the output have come to an agreement with the committee of the American Society of Mechanical Engineers, and, although the committee of the National Association of Master Steam and Hot Water Fitters has not yet accepted the compromise, it is practically certain that the double standard, which for two years or more has threatened, will be avoided, and that we shall settle down to one American standard, acceptable alike to the manufacturer and user.

To meet the wishes of the waterworks engineers the dimensions for standard fittings have been given up to 100 in. in diameter instead of to 48 only, as before, and of the extra-heavy fitting up to 48 in. instead of only to 24 in. as before.

What Is the Use?

This expression has been used, probably, by every reader, as a reason why some piece of work should or should not be done, or why some particular effort should, or should not, be made. It is a natural and sensible question to ask under some circumstances, but shows lack of forethought in others.

If a new power-plant apparatus is suggested the engineer wants to know "what is the use" of putting it in. Will it assist in making a better showing in the plant economy, or will it fail to assist in the operation? If the apparatus is installed because one is used in another plant where operating conditions are radically different and if it cannot produce results commensurate with the cost, then it is of no use, from a monetary standpoint.

All too often, however, the expression "what is the use?" is the result of indolence on the part of the engineer. The boiler room is dirty and untidy; tools are scattered here and there, coal covers the floor, the ashpit is nearly filled with ashes and the boiler setting is badly cracked. Ask the attendant why these conditions are not changed and the answer will doubtless be, "What is the use? I will get my week's pay just the same without doing the extra work."

If the fireman is contented to remain in the same position, year after year, without advancement, working for less than two dollars a day, in some cases working twelve-hour shifts, there is no use in trying to better his own or the condition of the plant, if he can manage to hold down the job.

An engine knocks, requires valve adjusting, is dirty, but still manages to turn over during the working hours, regardless of the amount of steam consumed. Ask the engineer why he does not attend to the engine and the reply will be, "What is the use, the engine runs, doesn't it, what more do you want?"

From the standpoint of such an engineer, nothing more can be expected, what is the use? Contented to draw his pay, content with allowing the engine to run itself, such a man will spend his time in a battered, makeshift chair, content with his surroundings and with himself.

Ambition to run a better and larger steam plant possesses the average young engineer. He has sense enough to know that there will be but slight possibilities of his assuming control of larger plants unless he prepares himself for the position. *What is the use* of idling away days by not preparing to make use of opportunities when they appear? *What is the use of* grumbling at the apparent luck of others who reach the better and higher positions, when no effort has been made on the part of the disgruntled one to fit himself to fill the place? *What is the use* of being discontented with existing conditions, when no real effort has been made to change them?

The men who occupy the desirable engineering positions do not do so by chance, at least not often and then not for long. The men who operate the small undesirable steam plants do not do so because fortune has not favored them; not as a rule. Both classes of engineers occupy the position for which they are fitted.

If a man has no desire to advance to a better plant, earn more money and get more out of life, there *is no use* in his doing anything else but hold down the old job with the dirty boiler room and thumping engine. But what kind of an engineer is he?

The Thief Discovered

For a long time we have been receiving complaints that remittances sent by our subscribers were unacknowledged, and that in many cases a second claim was made for money already sent.

At last the culprit has been found in one Charles Moscovitz, a clerk in the New York City General Post Office, who, at the time of his arrest by post-office inspectors, had thirteen letters addressed to POWER concealed in his right sock. Moscovitz is alleged to have said that "he had no excuse to offer and that he was prepared to take his medicine." The federal authorities believe that his stealings cover a period of nearly nine years.

Between Jan. 1 and Sept. 20 of this year there were 658 letters containing remittances which failed to reach this office. This is over three letters for each working day, entailing a loss of between one hundred and fifty and two hundred dollars a month.

Our greatest concern, however, has been for the trouble, dissatisfaction and annoyance which has been occasioned to our subscribers. Our wish is, of course, that every man who pays for the paper should get it regularly. Our strength is in our circulation. When you send money by mail, make it as little apparent as possible that it is money; remember when and where and at what time you mailed it and the sort of envelope used, and if you don't get an acknowledgment or do get another bill, don't cuss POWER, let us know at once.

Your bookkeeper will probably be glad to give you a check in exchange for your cash, and if a Moscovitz gets that he cannot use it, while its nonreturn through the bank will show that we did not get and use it.

The New Man

Any engineer who has had the experience knows how unpleasant it is to be put in charge of a plant without having time to become acquainted with the peculiarities of the place before his predecessor quit the job. Usually it is such a disagreeable situation to find oneself in that the victim will, if he is honest, resolve never to leave a job until he has "broken in" his successor, if possible.

Power plants are somewhat like men—no two are alike. Each has its characteristics, individually trivial, but the cumulative effect of them is such as to warrant individual consideration to avoid inconveniences. Minor troubles are often discouraging to a new man, although he should not be too easily disheartened. But if these small troubles which worry and often seriously confuse nearly every man, can be avoided by having his predecessor remain with him for a week or two, why not have him there?

Take a man who is familiar with central-station work or the plants of manufactories only and place him in charge of a large office-building or department-store plant. Suppose that man were you? Would you not do your work better, would you not feel more favorably inclined toward the management if your predecessor were allowed to remain with you for a while? Of course you would.

The management is likely to fail to understand this as well as the engineers do and hence they should be informed of the need of getting the new man on the job a week or so before the old one leaves.

Four hundred million dollars a year can profitably be used in the development of electrical industries in the United States during the next five years, says Frank A. Vanderlip, president of the National City Bank of New York. Such figures are staggering and one might be inclined to accuse Mr. Vanderlip of being over-optimistic. In support of his statement, however, he cites statistics to show that the investment in central-station properties increased during the period 1902 to 1907 from five hundred million to one billion dollars. Although the figures for the last five years, 1907 to 1913, are not complete, they indicate a present investment of over two billion. At this rate, Mr. Vanderlip's prophecy seems reasonable.

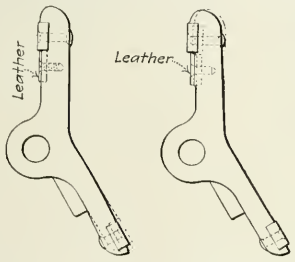
Whether the rate of increase has reached a maximum is hard to tell, but it is certain that the field for electricity in industrial lines is continually broadening and the electrification of railroads is progressing, slowly perhaps, but surely. Moreover, electricity is no longer regarded by the public in the light of an experiment; hence such investments should attract capital, especially in view of the guarantee against so called "high finance," now afforded by public-service commission supervision.

The Central Union of German manufacturers has adopted a resolution declaring that the great majority of German manufacturers are absolutely opposed to participating in the Panama-Pacific Exposition, and thanking the German government for its attitude. The protestations that the restrictions placed by the United States upon foreign products make it impossible for German industry to obtain any advantages by participating in the San Francisco Fair, would have been just as true of Chicago or St. Louis, where Germany had extensive and creditable displays.

READERS WITH SOMETHING TO SAY

Experience with Old Brown Engine

Like many engineers, I eventually had charge of an l-type Brown engine, a four-valve gridiron-valve engine ving the valves and governor operated from a layshaft nning under the frame, and connected to the main aft by bevel gears. Small eccentrics on the side shafts e connected to levers which engage the latches that lift e valve. As with other four-valve engines of the re-



SHOWING HOW BADLY THE LATCHES WERE BENT

se gear, these latch blocks must be kept in good condi-n to insure good running and economical operation. Although this engine was not in bad shape, some of e pins were badly worn. The indicator was put on the gine, and some peculiar diagrams taken. Then the ls were turned around and as much lost motion taken as possible. The indicator cards improved, but showed greater mean effective pressure on one end of the cylin-r than on the other. This was a puzzle, as the valves re carefully set according to the shop marks. I noticed at one of the latches seemed to be closer to the tripping er than the other. Thinking that one of the tripping ers had been set farther forward on the rockshaft than e other, I loosened it to set it back, and thus equalize e cutoff. To my surprise the rockshaft had been otted" for the setscrew, and the lever was set at the p mark. Before taking out the rockshaft, I concluded put on new latch blocks, and so removed both latches. chance I got them side by side edgewise, and then I ticed that there was a difference of 1/8 in. in their gles.

The end of the latch, Fig. 1, was sprung 1/16 in., as e dotted line indicates, while the latch on the other d resembled Fig. 2. This was the reason why the toffs could not be equalized. It could be done, but the extra shims required on the tripping levers were likely to have the effect of changing the position of the governor, and possibly cause unsteady operation of the engine. The latches were bent by holding them over the edge of an anvil while riveting on the case-hardened blocks.

To see what effect changing the thickness of the plates on the ends of the latches would have on this type of an engine, I experimented by putting tin shims on the tripping levers of the rockshaft. Fig. 3 shows a diagram from each end of the cylinder with a shim 3/4 in. thick added to the tripping lever on the crank end. Fig. 4 shows a 1/2-in. shim added to the head-end tripping lever, while Fig. 5 is a normal diagram.

R. A. CULTRA.

Cambridge, Mass.

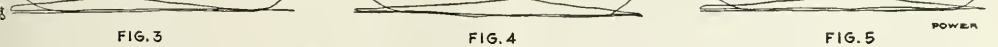


FIG. 3 FIG. 4 FIG. 5

BROWN ENGINE DIAGRAMS, SHOWING EFFECT OF PUTTING SHIMS IN TRIPPING LEVERS

Air-Receiver Inspection Needed

Much ado has been made, especially in some of the Central states, over the criminal carelessness of engineers employed at mines. That compressed-air plants, in many instances, are operated under dangerous conditions is known no better than by some of the engineers themselves. But, these engineers may be working under orders which to disobey would mean the loss of their jobs, and many an engineer with a small salary and a large family would take a chance on his life as soon as take a chance on his job. But if any plant so operated be put under state inspection and the engineer in charge given to understand that any neglect or carelessness will mean dismissal, then orders will be obeyed and conditions will become safer.

That there are more explosions of air receivers than of boilers according to the number of each in use is a proof of what inspection will do toward rendering a plant safer, for many air receivers are not subjected to state or insurance inspection.

If, too, an explosion occurs in a plant not under state or insurance inspection and operated by a non-licensed man, then no one competent is compelled to make a thorough investigation and "the can is usually tied to the wrong man" while the plant still continues to be operated in the same dangerous manner. If, by chance, the blame is put on the right party he simply looks up another job and goes on as before.

But, let an explosion take place in a plant under state inspection and operated by licensed engineers, then, a

thorough investigation is made by a competent inspector, who will find the right man, have him discharged and his license revoked, which will be a guarantee that he will not have the opportunity to do the same thing again.

The writer has been employed as operating engineer in eight different compressed-air plants, six of which were operated under dangerous conditions.

The following observations were made concerning those operated under state inspection and those that were not:

Total number of air compressors operated with receiver connections	44
Total number (including receivers) under state inspection	0
Total number (including receivers) under insurance inspection	0
Total number explosions	4
Total number men discharged on account of explosions	0
Total number licenses revoked	0

Boilers operated in connection with these eight plants as follows:

Total number operated	39
Total number under state and insurance inspection	22
Total number under state inspection only	26
Total number under insurance only	2
Total number under neither state nor insurance inspection	11
Total number of explosions	1
Total number men discharged on account of explosion	1
Total number licenses revoked	1

The above table, though somewhat meager, seems to me to substantiate the theory that state inspection will bring about the safest possible conditions for boilers, air receivers, etc., while insurance inspection, though more limited in its authority, will do much toward lessening the number of explosions.

R. S. Hart.

Stockett, Mont.

Nozzles for Washing Boilers

In ordinary washing of return-tubular boilers it is customary to depend upon the impingment of a stream of water from the nozzle of a hose introduced through handholes or manholes in the boiler. The process is anything but effective in removal of scale and mud which might be loosened and washed from the surfaces of the

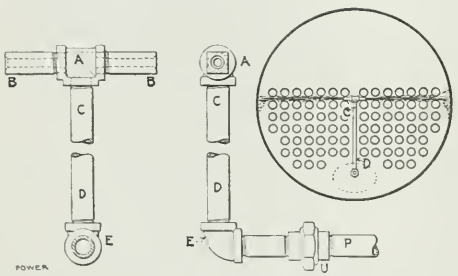


Fig. 1. Nozzles for Washing Boiler Tubes and Shell

tubes and shell if subjected to the erosive action of a stream of water of high velocity, directed normally to the tube and shell surfaces. The use of a bent pipe for directing the stream of water to various parts of the boiler at best is suitable for reaching only portions of the tubes and shell surfaces and the upper and lower surfaces of the tubes receive little or no benefit.

For overcoming these difficulties I have constructed nozzles such as shown in the accompanying sketches and by their use, supplied with water at 100 to 125 lb. pressure from a house-tank pump, have been enabled during the past two years to keep the tube and shell surfaces of my boilers clean with noticeable improvement of boiler economy and steaming capacity.

Referring to Fig. 1, *A* is a ¾-in. tee into which are screwed nozzles *B* and *B*, which are made from 1-in. square steel, each nozzle being bored its full length with a hole ⅜ in. diameter counterbored at each end, as shown by the dotted lines. The pipe *CD* is connected to *A* and is provided at its lower end with an elbow *E*, short nipple

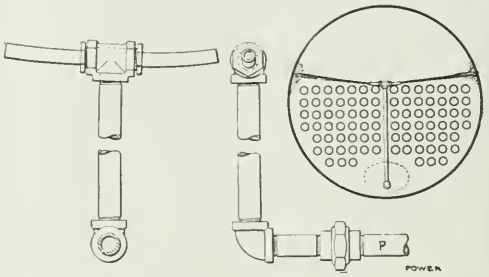


Fig. 2. Nozzles for Washing Boiler above Tubes

and brass ground spanner union for coupling the nozzle pipe to a reach pipe *P*.

The nozzle pipe *CD* being detached from *P* is readily introduced through a manhole or handhole near the bottom of the boiler and the nozzle end raised up between the tubes.

By then turning the nozzle pipe 90 deg., as shown in the cross-sectional view of the boiler, it may be supported on the middle pair of a horizontal row of tubes, as shown in Fig. 1, at a height depending on the length employed for the nozzle pipe *CD*, and by means of the union *U* connected to a reach pipe supplied with water through a high-pressure hose connected to a pump or other source of high-pressure water supply. When thus connected, the water supply being turned on, the nozzle pipe by means of the reach pipe is moved from one end of the boiler to the other, while powerful jets of water are projected between the tubes, impinging on the sides of the shell and the upper and lower sides of the tubes, as illustrated in Fig. 1.

The object of making the nozzles *B* of square steel is that they may act as scrapers for removal of any deposit formed on the upper or lower sides of the tubes between which the nozzles are passed.

For washing the tubes of our 66-in. boilers we use three different lengths of nozzle pipes like *CD*, and for washing the shell above the tubes use nozzles formed of bent pipe, as shown in Fig. 2 with duplicate coupling fittings for attaching the nozzle pipes interchangeably to the reach pipe *P*.

Boiler-washing nozzles of the kind described can be made up of materials to be found in most any power plant at only a nominal cost of construction and when used at proper intervals with water at high pressure will be found to give satisfactory results.

The efficiency of these nozzles in cleaning boilers, when used with high pressure of water, is remarkable.

A. E. Bornmann.

New York City.

QUESTIONS BEFORE THE HOUSE

Soda-Ash for Boiler Waters

A very serious and readily evident error appears in my article under the above head in the Sept. 16 issue, page 412.

It is stated that 275.13 lb. of soda ash is needed to make a solution of 3 per cent. normal alkalinity with 5000 lb. of water, which is the amount that a 100-hp. horizontal tubular boiler will contain when full to normal water level. This amount is greatly excessive, owing to the fact that 55 grams is given as the amount of soda-ash necessary to produce a 3 per cent. normal solution with 1 liter of water. A normal solution contains 53 grams per liter; a 3 per cent. normal solution will contain

$$53 \times 0.03 = 1.59 \text{ grams per liter}$$

and a gallon of 3 per cent. normal solution will contain

$$1.59 \text{ gr.} \times 3.79 \text{ liters} = 6.02 \text{ gr.}$$

A 100-hp. horizontal tubular boiler containing 5000 lb. of water will require

$$600.24 \text{ gal.} \times 6.02 = 3613.44 \text{ gr., or } 7.97 \text{— lb.}$$

of soda ash to bring it up to 3 per cent. normal alkalinity.

It is unfortunate that the error occurred, but as it is so evident, it is hoped that all who read the article immediately discovered it.

CHARLES H. BROMLEY.

New York City.

Power-Plant Vibration

The article by F. H. Davies on the above subject in the Aug. 12 issue of POWER prompts me to write the following:

Several years ago an engine was installed in one of the scientific bureaus in Washington. The upper floors of the building were occupied by instrument-testing laboratories, the work in which would be disturbed by excessive vibration. For this reason the engine foundation was built entirely isolated from the engine-room floor, a space of about ⅛ in. being left between them.

The soil in this vicinity is dry and of a stable character and will not conduct vibrations to any great extent. As shown by the sketch there is a sub-basement under the engine-room floor, and it was thought that dirt falling into the ⅛-in. insulating space would fall through into the basement. For some reason, however, the floor of the foundation seemed to spread gradually, until in time the insulating space was entirely closed in places, with a consequent increase in the vibration transmitted to the building.

Recently another engine was installed in the same building and a modification of the method first used with satisfactory results. Fig. 1 shows the general layout of the foundation with relation to the surrounding floors. Fig. 2 is intended to show more clearly the method used to provide a cover to the 2½-in. insulating space. A cover was deemed advisable for this space to prevent a possible accident to persons walking around the engine. Strap irons were fastened to the floor and foundation in the manner illustrated, the lugs and bolts being imbedded in the concrete as it was poured into the forms. On the

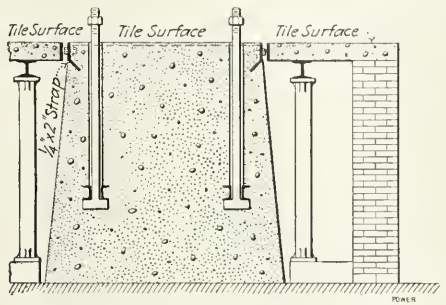


FIG. 1. FOUNDATION AS FIRST DESIGNED

foundation side the bolts fastening the straps to the imbedded lugs, were placed so that a ¼x2¼-in. strap iron laying on the bolt heads would level up the insulating space. The strap iron is a little less in width than the space in which it lies. This arrangement effectually prevents the transmission of vibration from the engine to the

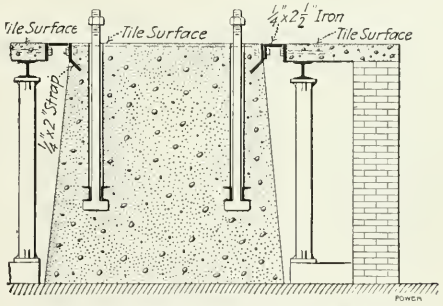


FIG. 2. MODIFICATION OF FIRST METHOD OF JOINING FLOOR TO FOUNDATION

floor and there is no foot trap around the engine to cause an accident.

H. G. GIBSON.

Washington, D. C.

Mr. Davies' article was read with interest, and it is hoped that it may prompt others to contribute to the literature on the subject. Vibrations in plants of hotels, office buildings, apartments, etc., is often difficult of elimination.

H. C. MARKUS.

Cleveland, Ohio.

INQUIRIES OF GENERAL INTEREST

Running Without Riding Cutoff—How could an engine be kept running temporarily if the riding cutoff gave out?

R. B.

In an ordinary Meyer riding-cutoff valve gear, by removing the cutoff valve from the steam chest, the distribution of steam could be effected by the main valve working as an ordinary slide valve, cutting off at the longest distance the steam would be admitted in ordinary operation. If the cutoff valve of the engine were operated direct by the governor, it would be necessary to control the speed of the engine by the hand throttle valve or by a throttling governor.

Effect of Advancing Eccentric—What would happen if the eccentric of a Corliss engine were advanced 45 deg. beyond the right position?

R. B.

The events, as admission, release and closure of the exhaust, would occur one-eighth of a revolution earlier. Admission would create so much back pressure before completion of the return stroke, opening of the exhaust would occur so soon after cutoff and compression of exhaust would begin so soon in the return stroke, from early closure of the exhaust, as to leave the engine capable of developing very little, if any, power.

Preventing Boiler Corrosion—When installing a new boiler can graphite or anything else be used to prevent corroding and pitting and keep the plates and tubes tight and free from rust?

B. R.

It would be best to give the inside of the shell and water side of the tubes a thorough coat of graphite paint when the boiler is made, before the tubes are set in the boiler. If the boiler is already constructed, paint all interior surfaces that can be reached and use sufficient graphite introduced with the feed water to form a good coating of graphite. It will hinder corrosion and prevent adhesion of scale.

Moisture in Oil-Fuel Burning—In conducting tests of our oil-fuel-burning boiler we have obtained results that vary perceptibly while the conditions of boiler, burner, etc., have been uniform. Atmospheric conditions have varied from dry to humid days. Has humidity any effect on boiler efficiency?

L. B. D.

Yes, during the oil-fuel-burning tests conducted by the Bureau of Steam Engineering of the navy it was found that a decrease in efficiency was produced by humidity, due to two causes: To the displacement of an amount of oxygen in a given volume of air by the moisture in the air, which requires an excess in volume of air for completing combustion, with consequent loss of heat in the stack; to the decreased rapidity of diffusion of the combustible gases with oxygen due to the presence of inert moisture.

Difference of Boiler Pressures—When two boilers, say one of 250- and one of 200-b.hp. capacity, are connected to the same steam line, what can cause one to show a higher pressure than the other?

F. H. K.

When for any reason either of them generates steam faster than it can be discharged into the steam line, then the pressure will rise in that boiler and faster than in the other, just as might happen if one boiler had its main stop valve partly closed. The same relative conditions might exist from the throttling action of the steam-pipe connections of one boiler being different from the other, and, as the relative throttling action varies for different rates of steaming and different discharging pressures, the pressures in two boilers connected to the same steam pipe are seldom absolutely the same, and their difference is constantly changing with the variations in intensities of their furnace fires.

Air Receiver Pound—What may be the cause of a pound in the receiver of an air compressor and how may it be stopped?

F. B.

The best way to trace the cause of the noise is to run the compressor only just fast enough for the hammering to take place. Then observe whether it may not be due to the noise of sudden seating of the check valve being conveyed to the receiver. A larger check valve might remedy the trouble, or a muffler placed between the check valve and receiver would probably prevent the noise being carried to the receiver. Such a muffler could be a cylinder of cast iron of about three times the diameter of the air pipe and about four times as long as its own diameter, divided by partitions into about five compartments with each partition cut out in the center by a hole the size of the main air pipe.

Pump Would Not Work—Can a pump with a 4-in. diameter steam cylinder and 3-in. diameter water cylinder deliver water into a boiler 20 ft. above it carrying a pressure of 100-lb. gage?

C. A. R.

The pump has to overcome the pressure due to 20 ft. head of water in addition to the boiler pressure. As each foot of head would create 0.433 lb. the pressure due to 20-ft. head would be

$$0.433 \times 20 = 8.66 \text{ lb. per sq.in.}$$

The pressure from the boiler being 100 lb., the total to be overcome by the pump would be

$$100 + 8.66 = 108.66 \text{ lb. per sq.in.}$$

The pressure acting in the steam cylinder would be its area in square inches, multiplied by 100 lb., i.e.,

$$12.566 \text{ sq.in.} \times 100 = 1256.6 \text{ sq.in.,}$$

and as a 3-in. diameter water piston has an area of 7.0686 sq.in., neglecting friction, the resistance to motion of the water piston would be

$$108.66 \times 7.0686 = 768.074076 \text{ lb.}$$

The mechanical efficiency of the pump would have to be

$$\frac{768}{1256} = 61 \text{ per cent.}$$

As this efficiency for small pumps is rarely above 50 per cent., it is not probable that a boiler-feed pump would operate under the conditions stated.

Determining Heater Size—How does one arrive at the size of open feed-water heater required under given conditions?

F. E. B.

The proportions will vary depending on numerous conditions such as the character of the water, the arrangement of the trays, etc., but generally the size of the shell for a cylindrical heater should be approximately as follows:

$$A = \frac{H}{aL}$$

or

$$L = \frac{H}{aA}$$

in which

A = Sectional area of shell, square feet.;
L = Length of shell, feet;
H = Water to be heated per hour divided by steam used per horsepower per hour by the engine, pounds;
a = Constant depending on the kind of water—very muddy, 2.15; slightly muddy, 6; clear, 8.

Some modification in the pan or tray surface will be necessary according to the quality of the water, but in relation to mud- and scale-making ingredients, the surface in square feet for each 1000 lb. of water heated per hour may be taken as follows:

For the vertical type of heater:	
Very bad water	8.5
Medium muddy water	6
Clear and little scale	2
For the horizontal type of heater:	
Very bad water	9.1
Medium muddy water	6.5
Clear and little scale	2.2

Between rectangular pans the space should be not less than one-tenth their width, or for round pans one-quarter their diameter, and about a quarter of the total depth should be left for a storage and settling chamber.

ENGINEERS' STUDY COURSE

Boiler Efficiency—II

Before starting a test all instruments and weighing or measuring apparatus should be examined and put in good order and, where deemed necessary, they should be tested for accuracy. If possible, the blowoff and other water connections that can be dispensed with temporarily, such as an extra feed pipe, should be disconnected and sealed with blank flanges. This is to eliminate the danger of error due to water leaking out without being evaporated. The boiler should be examined both outside and in and a full memorandum of its condition during the test, as indicated by this preliminary examination, should be included in the report. This may be of value in explaining why the results secured are good, bad or indifferent, as the case may be. If the test is for the purpose of ascertaining the highest obtainable capacity or efficiency, the boiler, furnace and setting should be put into the best possible condition.

Duration of Test

The necessary length of the test will depend on its purpose and, somewhat, on local conditions. The greater the duration the less will be the effect of the errors that occur at the beginning and ending. Where the test is run under actual working conditions a duration of 24 hr. yields data on all conditions of load and operation. However, it is not always possible or convenient to conduct a test of that length and, hence, a shorter one is often made to suffice. One of 8 hr. is about as short as is safe if any dependence is to be put upon it; a 10-hr. one is better.

Starting and Stopping Test

Unless proper care is employed errors are likely to occur at the beginning and ending of a test. Effort should be made to have conditions at the start and the finish as nearly the same as possible; the steam pressure and water level, also, the size and condition of the fire should be as nearly equal as possible.

The code of the American Society of Mechanical Engineers outlines two methods of starting and stopping. One is called the "standard" method and the other, the "alternate" method. The first mentioned one consists of drawing the fire just before the start and building a new one on the clean grates, dating the start from the time a new fire is lit.

At the end the fire is burned thin and drawn, the finish being dated at that time. This method is open to criticism as there is considerable chance for error, due to the boiler being cooled when the fire is drawn at the start and finish. In addition, this method is considerably less convenient than the alternate method. The latter is as follows:

See that the boiler has been thoroughly heated by a preliminary run of suitable length at the working pressure. Burn the fire low and clean it well. Then make an estimate of the thickness and condition of the fire and make a memorandum of this. Note the time and record this as the starting time of the test and, then, proceed with periodic observation of the various pressures, temperatures, etc. Stoke the fire with coal that has been weighed and keep a record of the amount used. In the same way, keep a record of the feed water pumped, starting with the time that is recorded as the beginning of the test.

As soon as the test is started, clean out the ashpit thoroughly and throw away the ashes thus collected as they are not to be entered in the test report. Before the end of the test the fire should be burned low, just as before the start and then cleaned so that it will have as nearly as possible the same thickness and condition as at the start. Likewise, bring the water level to as nearly as possible the same height as at the start. One way to gage the thickness of the fire is to drop the rake into it so that the tines touch the grate bars and then note the distance they have been buried in the fuel bed. For convenience in keeping the water level uniform a string is tied around the gage-glass at the level of the water at the start. With an automatic feed-water regulator this is unnecessary but still it is a good thing to have the string there simply as a check on the regulator.

Test Report

Table 1 shows the standard form of reporting boiler tests. It has been slightly changed and abbreviated to suit practical cases and filled in with data from an imaginary test so that it may be taken as a model for regular use.

The number of men required to conduct a test depends upon the number of different observations to be made, the interval of time between them and the arrangement of the boiler accessories and testing apparatus; hence, no definite directions can be given on this matter. If all readings are taken every 15 min., which is the customary interval when complete data are desired, in addition to one man for measuring and recording the feed water and one man for the coal, at least one extra man will be required to analyze the flue gases and perhaps a fourth man will be needed to observe temperatures, pressures, etc. Each man should be provided with a suitable chart or paper which should, if necessary, be ruled off so that the time of each reading as well as the reading itself may be noted down without confusion and undue danger of error. At the end of the test each set of readings is added up and divided by the total number of times which that particular reading has been recorded so as to get the average, which is then entered in its proper place on the report form. The total coal and water quantities are also entered upon the report, as indicated in Table 1.

In order to present an actual practice problem with which those who wish may test their grasp of the subjects involved, only data and not results have been en

tered in Table 1. The results and the calculations necessary to estimate them will be given in full in next week's lecture. The average temperature shown by the thermometer on the exhaust side of the calorimeter may be taken as 272 deg., for the imaginary test.

TABLE 1. BOILER-TEST REPORT FORM

Data and results of evaporative test made by..... Arthur Jones and assistants
Of....A Heine type water-tube boiler
At....Plant of Smith Mfg. Co., New York City.
To determine....Efficiency under actual operating conditions.

Kind of fuel	No. 2 buckwheat
Kind of furnace	Hand fired with shaking grates
State of weather	Fair, with average temperature at 37 deg
Method of starting and stopping	Alternate
Date of test	Feb. 13, 1913
Duration of test	10 hr.

Dimensions and Proportions

Grate surface	Width, 8 ft. 10 in.; length, 7 ft.; area, 62 sq.ft
Height of furnace	34 in.
Water-heating surface	2150 sq.ft.
Superheating surface	None

Average Pressures

Steam pressure by gage	103 (abs.) lb. per sq.in.
Draft at damper	0.9 in. of water
Draft in furnace	0 6 in. in water
Difference in draft between furnace and damper	0.3 in. of water
Difference in draft between ashpit and furnace	0 6 in. of water

Average Temperature

Air in fire room	92 deg.F.
Feed water entering boiler	199 deg.F
Gases escaping from boiler	540 deg.F

Fuel

Total weight of coal as fired	10,372 lb
Moisture in coal as fired	7 percent
Total weight of dry coal supplied to furnace	lb
Total weight of ash and refuse	1897 lb
Percentage of ash and refuse in dry coal	lb

Proximate Analysis of Coal

	Coal as fired per cent.	Dry coal per cent.	Combustible per cent.
Moisture	7		
Volatile matter	3 49		
Fixed carbon	76 35		
Ash	13 16		
Total	100		

Analysis of Ash and Refuse

Combustible matter	per cent.
Incombustible matter	per cent.

Fuel per Hour

Dry coal consumed per hour	lb.
Dry coal per sq.ft. grate per hr.	lb.

Heat Value of Fuel, B.t.u. per Pound

	Coal as Fired	Dry coal	Combustible
By calorimeter		12,600	
Estimated			

Quality of Steam

Moisture in steam	per cent.
Superheat	deg.
Total weight of water fed to boiler	83,125 lb.

Water per Hour

Water fed	lb. per hr
Water actually evaporated (corrected for moisture in steam)	lb. per hr
Factor of evaporation	
Actual equivalent evaporation	lb. per hr

Horsepower

Horsepower developed	
Builders' rated horsepower	220
Percentage of builders rating, developed	

Economic Results

Water apparently evaporated, actual conditions per pound of coal as fired	lb
Actual equivalent evaporation per lb. coal as fired	lb
Actual equivalent evaporation per lb. dry coal fired	lb
Actual equivalent evaporation per lb. combustible burned	lb

Efficiency

Efficiency of boiler (heat absorbed per lb. comb. burned divided by heat value of 1 lb. comb.)	per cent.
Efficiency of boiler and grate (heat absorbed per pound of coal fired divided by heat value of 1 lb. coal)	per cent.

Cost of Evaporation

Cost of coal per ton of 2,000 lb. delivered in furnace	$2 90
Cost of coal used for evaporating 1,000 lb. water from and at 212 deg.	

Analysis of Flue Gases

Carbon dioxide (CO_2)	10 7 per cent.
Oxygen (O)	8 7 per cent.
Carbon monoxide (CO)	0 4 per cent.
Nitrogen	

Method of Firing.

Kind of firing (spreading, alternate or coking)	spreading
Average thickness of fuel bed	5 in.
Average time between firings for each furnace during time when fires are in normal condition	11 min.
Average time between leveling or breaking up	32 min.
Average time between cleanings	5 hr.

Industrial Power in the United States

Increased use of gas engines and of electric power, especially the latter, is the most striking and significant showing made in the abstract of figures from the thirteenth census, tabulating the figures as to engines and power used in the manufactures of the United States. It has taken the Census Office nearly three years to make this compilation, the figures given being for 1909.

The total horsepower of electric motors in use in 1909 was 4,817,140, as compared with 492,936 in 1899, or an increase of nearly a thousand per cent., while the number of electric motors increased from 16,891 in 1899 to 73,119 in 1904, and in 1909 was 388,854. The increase in the number of gas engines in use in the last five-year period was nearly twice as great as in the first half.

Total horsepower of manufacturing establishments was 18,680,776 in 1909, as compared with 13,487,707 in 1904 and 10,097,893 in 1899. Ninety per cent. of the horsepower in 1909 was that of motors owned by the manufacturing establishments, and 10 per cent. was rented power, most of the latter being electric.

The primary power used, with the kind of engines, is shown in the following table. These figures exclude duplications, and the secondary power is not represented in the total given.

Power	Number of Engines or Motors			Horsepower		
	1909	1904	1899	1909	1904	1899
Primary power total	408,472	231,363	168,143	18,680,776	13,487,707	10,097,893
Owned	209,163	169,774	168,143	16,808,106	12,854,805	9,778,418
Steam	153,482	127,267	130,710	14,202,137	10,825,348	8,139,579
Gas	34,352	21,515	14,334	754,083	289,423	134,742
Water wheels	20,126	19,595	23,099	1,807,144	1,641,949	1,454,112
Water motors	1,203	1,397	(*)	15,449	5,931	(*)
Other				29,293	92,154	49,985
Rented	199,309	61,589	(*)	1,872,670	632,902	319,475
Electric	199,309	61,589	(*)	1,749,031	441,589	182,562
Other				123,639	191,313	136,913
Total Electric motors	388,854	73,119	16,891	4,817,140	1,592,475	492,936
Current generated by establishment	189,545	73,119	16,891	3,068,109	1,150,886	310,374
Rented power	199,309	(*)	(*)	1,749,031	441,589	182,562

(*) Not reported.

Wide differences among the industries with respect to the kind of power and engines used are shown by the figures reported for the 43 leading industries of the country. While some of these differences are ascribed to geographical location of establishments, no attempt is made to explain which are due to this, and which are due to the character of machinery used and the adaptability of different kinds of power to the industries. The figures show a very large percentage of power generated by gas engines to be used in the manufacture of carriages and wagons, flour mills and grist mills, foundries and machine shops, blast furnaces, steel works and rolling mills, lumber mills and printing establishments.

Waterwheels are used mainly in four industries—cotton mills, flour and grist mills, lumber mills and paper and wood-pulp manufactures. In the last-named industry, 60 per cent. of all the power used in the industry, or 783,311 hp., is developed by waterwheels.

Despite the increasing hydroelectric development in the Rocky Mountain and Pacific states, at Niagara and in New England, steam continues to be the most important source of power in every state of the union except Maine and Vermont. The census figures do not attempt to show the use of various kinds of fuel in steam development, nor the amount of hydroelectric power developed, this latter important item being added in a total with all other secondary power developed.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

With intelligent development of the electrical industry, says a prominent financier, the next five years should absorb $400,000,000 a year. The size of this wad makes us believe that the p. f. must have included the operating engineers' salaries, too.

⁂

For a year and a half, Mrs. Lena Williams has taken complete charge of the day shift of the Westbury Electric Light & Power Co. plant, at Cookshire, Quebec, "with perfect satisfaction to the owners as well as to the customers." She is the daughter of the manager and the wife of the electrician. Now, now! Any lady who can get away with such a job is to be admired.

⁂

Massachusetts man declares that the public no longer believes electricity to be a luxury; that the rich and poor alike need and demand it. And yet in some homes you never hear the old man say: "Hey, Timmy, on your way out for the pint, slip down into the cellar and jab this quarter in the meter; the tungsten in the butler's pantry is getting dim!"

⁂

A central-station enthusiast would have us believe that coöperation, and not competition, is the life of trade. Many an isolated plant would gladly do a little coöperation if its competition, the central station, would loosen up.

⁂

The Federation of Trade Press Associations is convened in New York City at this writing. This organization is a publishers' "N. A. S. E.," and, similarly, in convention, we jaw each other for our mutual good. This federation represents 5900 folks drawing annually $12,272,000 in salaries on publications having an added expense annually of $15,000,000. Perhaps, in one of your few sour moments, you thought we overjawed you on the efficiency of your vocation. Well, as a good physician we took a dose of our own medicine, and now that we are purged of more or less bile, we feel better. You know that old feeling of "It hurts me more than it does you, my son"—well that's it exactly.

⁂

Roy Wright, over to Lyndon, Kan., opines that "where ignorance is bliss, 'tis folly to be a blister." Here's his reason:

"Engine Blows Up—The gasoline engine owned by Will Duncan, being used to furnish power for the rock crusher on the Warren farm just east of Lyndon, was rendered useless Friday, by an explosive induced by a lack of water. No one was hurt. The fire box and crown sheet were crumpled up like paper and the boiler iron was crystallized making those parts of poor junk."

Thanks, Roy. Our condolence to Will Duncan.

⁂

Our British cousin has been called undemonstrative, cold, reserved, but gracious Scott! the London "Electrical Review's" report of a railway disaster should completely telescope this opinion. After you read this introduction you will tell Hall Caine and Marie Corelli to precipitately retreat rearwardly:

"Lest we forget! Oh! that we could forget Aisgill! Oh! that we might for once shirk our duty and refrain from again perusing the ghastly details of one of the most heart-rending and pitiful of the avoidable catastrophes which have blackened the pages of British railway history. That we might wake up to find it to have been a distressing nightmare! That we might close the book and say: What a very sensational piece of holiday fiction! But it cannot be."

And there's two pages of this! Our sympathy always goes out to any stricken community, but this isn't sympathy, it's piddling drool!

⁂

It's a cold weather this winter, Mawruss! A high forehead with the sweetly sounding name of Kamerlingh Onnes has already produced a temperature of 426 deg. Fahr. below zero. Liquefied gas did it, but we don't want to prove it.

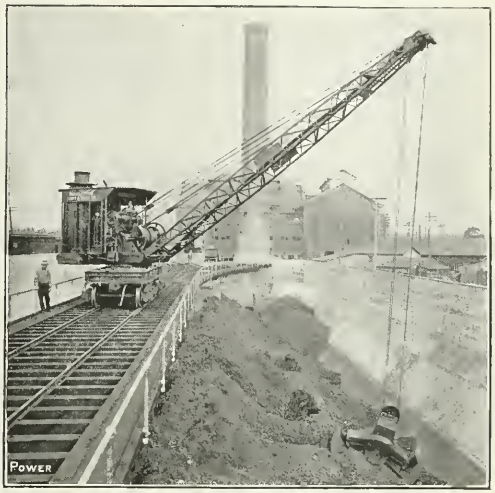
⁂

It would take over a thousand years to count the molecules in a cubic millimeter of hydrogen gas, says a French mathematician. All right, old man, we agree with you; we take the count.

Under-Water Coal-Storage Plant

A unique coal-storage plant has recently been erected by the Indianapolis Light & Heat Co., Indianapolis, Ind., where provision has been made for submerging 13,000 tons of coal under water to prevent spontaneous combustion. The plant has a total storage capacity of 30,000 tons and provides against coal shortage due to strikes at the mines or on the railroads and to car shortage on the railroads.

The plant consists of a large concrete pit, as shown in the illustration, 300 ft. long by 100 ft. wide and 28 ft. deep. It is 18 ft. below the ground level, having a 10-ft. wall rising above the ground. Below the ground the wall slopes at an angle of 45 deg. to reduce the cost of construction. This makes the pit 72 ft. wide by 272 ft. long on the bottom. The concrete is from 12 to 18 in. thick and is reinforced throughout with twisted ½-in. square rods to withstand any pressure from water that may occur in the gravel around the pit.



LOCOMOTIVE CRANE AND GRAB BUCKET

Through the middle of the pit, lengthways, there is a row of concrete piers placed 15 ft. apart which support a trestle on which there runs a standard-gage track. A standard 15-ton Brownhoist locomotive crane and 2-yd. grab bucket travels back and forth on this trestle, handling the coal on both sides. The bucket is suspended on a 40-ft. boom. The crane and bucket are operated by one man from his stand in the cab. Being self-propelled and equipped with M. C. B. trucks, couplers and steam brake, the crane does the switching of the cars off and on the trestle. The coal cars are run out on the trestle with the crane and dumped. When the coal is required in the power house it is loaded into cars by the crane and carried to the boilers.

Forty-pound rails are imbedded in the bottom of the pit, on 18-in. centers, with ½ in. of the head standing above the surface of the concrete. When the grab bucket is working on the bottom of the pit, the rails prevent the bucket from striking the concrete.

The pit is filled with water up to the ground level, and

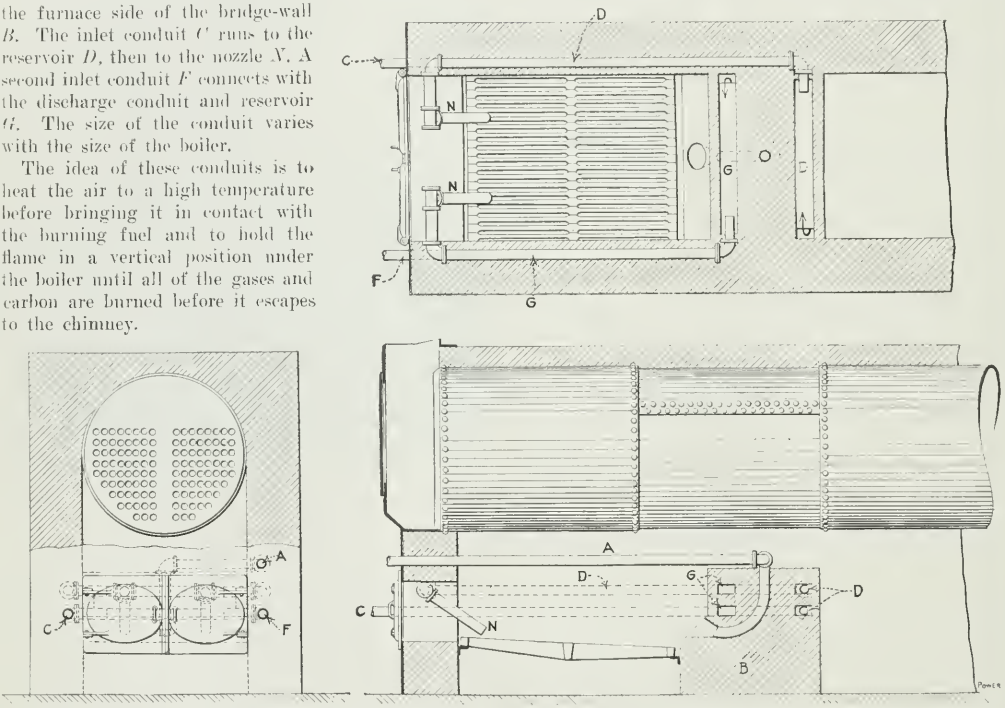
covers 13,000 tons of coal. Water is pumped into the pit by a 4-in. centrifugal pump, taking the water from the power-house supply well, the water entering the pit at the ground level. Through the center of the pit and beneath the trestle there is a trough 12 ft. wide and 1 ft. deep which serves as a drainage. It is fitted with a drain pipe which carries the water to either of two manholes, one at each end of the pit. The outlet openings are protected by gratings to prevent any coal from entering the drain pipe.

The pit was designed by Thomas A. Wynne, vice-president of the company, and was built under his supervision.

McKee Boiler Furnace

This furnace is designed to burn fuel efficiently with a minimum of smoke and to operate economically with a short chimney. In the accompanying illustration is shown an end, side and top view of the furnace applied to a return-tubular boiler. Referring to the side elevation, *A* is an inlet conduit through which air is discharged on the furnace side of the bridge-wall *B*. The inlet conduit *C* runs to the reservoir *D*, then to the nozzle *N*. A second inlet conduit *F* connects with the discharge conduit and reservoir *G*. The size of the conduit varies with the size of the boiler.

The idea of these conduits is to heat the air to a high temperature before bringing it in contact with the burning fuel and to hold the flame in a vertical position under the boiler until all of the gases and carbon are burned before it escapes to the chimney.



End, Plan and Side Elevation of the McKee Boiler Furnace

The air passes through the arrangement of conduits which run parallel with the line of fire from the front or the back of the boiler to the bridge-wall through a reservoir in the same and back to the ashpit of the boiler furnace and then comes in contact with the burning fuel. A counter-current of air is heated in a like manner and discharged in a forward direction from the bridge-wall toward the front of the furnace.

The furnace is built by the McKee Furnace Co., 108 Prince William St., St. John, N. B., Canada.

Spontaneous Ignition of Coal

By T. A. Peebles

Manufacturing establishments, central stations, and other users of large quantities of coal find it necessary to keep considerable quantities of fuel on hand to insure against labor troubles or delays in transportation. The coal thus kept in storage is in constant danger of spontaneous ignition, and in some cases expensive submerged storage bins have been installed or other elaborate precautions taken to prevent it. In cases where such construction is not practical, care should be taken to select for storage, coals which are least liable to spontaneous ignition, and a knowledge of the conditions affecting this ignition is, therefore, valuable.

The process of ignition may be divided into four separate stages:

1. Certain volatile constituents are present in coal which have an avidity for oxygen, and freshly mined coal begins to absorb oxygen as soon as it is exposed to the air. This primary stage of the oxidation process causes an increase in the temperature of the coal which may be considerable if the coal is finely divided and thus exposes a large amount of surface to the air.

2. If the coal contains an appreciable amount of iron pyrites, a reaction between the sulphur of the pyrites and oxygen will occur at ordinary temperatures. This reaction takes place rapidly, especially if the coal is wet, and heat is generated more rapidly than it is radiated from a large pile of coal, with the result that the interior

of the pile may reach a temperature at which oxidation of carbon and hydrogen begins.

3. The hydrocarbon compounds begin to break down at a temperature of about 250 deg., F., and if even a small amount of oxygen is present, this stage of combustion is extremely dangerous on account of the large amount of heat evolved.

4. After a temperature of 400 deg., F., is reached, the combustion of carbon and hydrogen goes on without the assistance of any outside source of heat, and heat is generated at such a rate that the cooling effect of radiation will not be sufficient to stop the process. Actual ignition of the carbons begins as soon as the temperature rises to 600 or 700 deg., F.

From the foregoing, it is evident that some coals are better suited for storage purposes than others. If the third stage of the ignition process be reached, actual combustion is almost sure to result eventually, and the first and second stages are, therefore, most important. The following points should be carefully considered as affecting the spontaneous ignition of coal in storage:

Avoid any external source of heat which may raise the initial temperature. For any given coal, a definite amount of heat is generated and if the initial temperature be high, due to the application of external heat, the danger of spontaneous ignition is increased. Coal stored in overhead bunkers in a boiler room where it is exposed to the heat of the boilers from below, and the heat of the sun radiated from the roof above, is almost sure to be ignited.

Dryness of the coal and provision for keeping it dry will greatly reduce the oxidation of iron pyrites.

Fine particles present large surfaces to the air for the initial stages of oxidation and the elimination of such particles from coal intended for storage is desirable.

When shipments of coal are being received, part of which is to be used immediately and the balance stored, that which is wet or very fine should be burned, and the coarser grades and those free from moisture put into storage.

Compensating Device for Water Measurement

On page 389 of the Sept. 16 issue was described a compensating device used with the Lea type recorder as manufactured under English patents. The instrument is known as the Precision Water Meter in this country and is made by the Precision Instrument Co., 102 Randolph St., Detroit, Mich., with the new compensating notch incorporated in its design.

Bangs (Ohio) Steam-Engine Wreck

On Sept. 11, about 4:30 a.m., the engine used for lighting the Logan Natural Gas & Fuel Co. pumping station at Bangs, Ohio, was wrecked. A correspondent furnishes the following details:

The babbitt in the crank bearing melted out, and an engineer closed the throttle only a moment before the wreck occurred.

The connecting-rod was of the marine type, setscrews took the place of lock nuts, and apparently a nut had worked nearly off, as no threads were stripped and one end was torn off. The bolts were badly bent, both halves of the crank bearing, the crosshead, and both crosshead shoes were broken; one of the low-pressure cylinder heads had a part of the flange broken off, and the cast-iron top cover to the crank case was broken as was the connecting-rod. The greater part of the crosshead and parts of both shoes flew out over the counterweights onto the floor. It was a 144-hp. tandem-compound engine, running at 260 r.p.m., and was directly connected to a direct-current 75-kw. dynamo.

Smoke Convention at Pittsburgh

The eighth annual convention of the International Association for the Prevention of Smoke was held in Pittsburgh, Penn., Sept. 9 to 12.

Among the papers presented was one on stokers for locomotives, by Mr. Crawford, superintendent of motive power for the Western division of the Pennsylvania Railroad. Mr. Crawford described the stoker and told of its success in producing practically smokeless combustion in locomotive furnaces.

Mr. Smith, of Glasgow, spoke on the favorable progress made in smoke abatement in Scotland.

The Committee on Standardization intends to present a thorough report on its work of standardizing furnace, chimnies, draft systems, etc., at the next convention in Grand Rapids, Mich. We hope to soon publish brief abstracts of Mr. Crawford's paper and of the Standardization Committee's report.

The new officers are: President, J. M. Searle, chief smoke inspector for Pittsburgh, Penn.; vice-president, Louis E. Towner, Grand Rapids, Mich.; secretary, John Krause, Cleveland, Ohio.

SOCIETY NOTES

The Smoke and Dust Abatement League of Pittsburgh is to be congratulated on the good results thus far attained in its work. Its exhibit at the Western Pennsylvania Exposition has drawn wide attention—by showing by charts, maps and drawings the serious loss yearly suffered by the city of Pittsburgh through smoke and dust. The exhibition will be open to the public until Oct. 18.

The Pennsylvania Industrial and Efficiency Convention, under the auspices of the Engineers Society of Pennsylvania, will be held in the Capitol Building, Harrisburg, Penn., on Oct. 28, 29 and 30. George S. Comstock, president of the society, will preside. Among others, papers will be read at the state-service session on vocational education, water power and water conservation; at the labor and statistics session, heat, ventilation and light; at the accident-prevention session, coöperative boiler inspection; elevators, their construction, inspection and maintenance.

Persons attending the conference are asked to notify the Department of Labor and Industry, Harrisburg, Penn., to that effect, and those who wish to make exhibits to write the Director of Exhibits, Harrisburg, Penn., in regard to space, etc.

PERSONALS

Herbert E. Stone, past president of the National Association of Stationary Engineers, has accepted a position with the Buckeye Engine Co., of Salem, Ohio, and will have charge of the New England district.

Albert E. Guy has just terminated a two-years' engagement with the Wilson-Snyder Centrifugal Pump Co., of Pittsburgh, Penn. In his capacity as chief engineer for that company, he designed and established their complete lines of single and multi-stage centrifugal pumps for steam turbine and motor drive. While still retained as consulting engineer, by that company, he will become, Sept. 15, mechanical engineer of the Providence Engineering Works, Providence, R. I.

An "Acre-Foot" of Water is equivalent to 43,560 cu.ft. and is the quantity required to cover an acre to the depth of 1 ft. The term is commonly used in connection with storage for irrigation.

What Has The Amer
Got To Do W

Ever hear the story of the rube who went to the circus?

Wandering into the menagerie he presently found himself in front of a cage containing a giraffe.

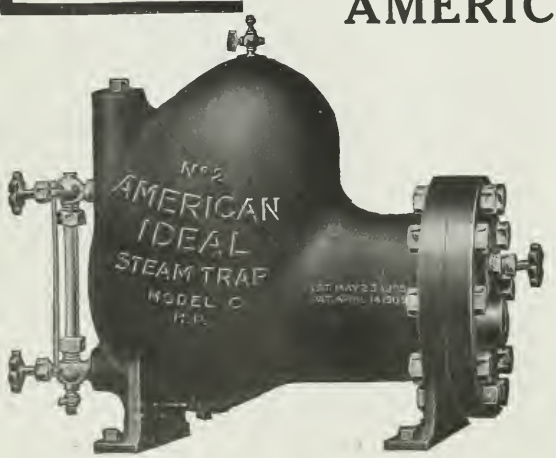
For a long time he stood looking at it, open-mouthed, then finally turned away with the remark, "Shucks; there aint no such animal."

Maybe that's much the same attitude you'll assume toward the American Ideal Steam Trap.

The things which this trap accomplish seem almost too good to be true. When you stop and think of what it does and how it promises to solve the big problem of meeting the very highest pressure you're likely inclined to say, "There isn't such a trap."

But just the same there IS—and it's the American Ideal.

The trouble you engineers have had in the past with traps which have failed to stand up to the severe requirements of very high pressures has made you skeptical.

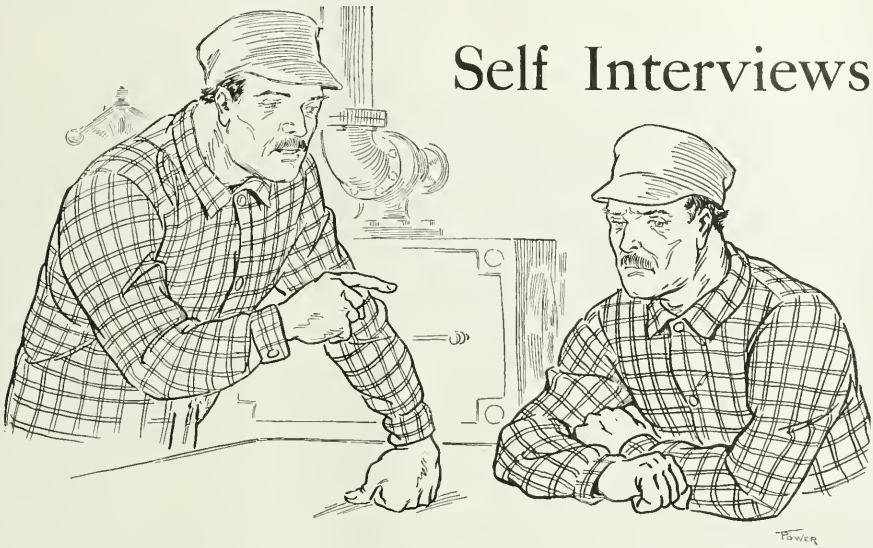


AMERICAN STEAM GAUG
CAMDEN STREE

POWER

Vol. 38 NEW YORK, OCTOBER 7, 1913 No. 15

Self Interviews



THE place might have been any ordinary power plant: the time, any old time at all. John Operating Engineer sat at his desk in melancholy meditation, when in came John Operating Engineer.

□ □ □

"Good morning," says John, "what can I do for you?"

"Much! But first I'm goin' to give you a tongue lashing."

"Since you had that flare up with the general super, you've neglected things. You've said you didn't care whether you got fired or not. It's all right to be independent, but your reputation will suffer if you let the plant go to the dogs just because you're sore at one official."

"True," snapped John Operating Engineer, "but when they treat a fel—"

"That's no e x c u s e! That m a i n belt snapped yesterday simply through neglect. You let it go until so many holes broke through that it wouldn't drive a buzz-saw. When you took an hour longer than necessary to lace it, just to get square with the super you didn't think of the piece-workers who lost a good part of a day's pay, did you?

"That high-pressure steam line under the street was put down without being covered or boxed. Now it's corroded and leaks like a funnel. You're delaying repairs to it, hoping it will burst, shut down the shop and get the boss into trouble."

"He's no good, he ought to," growled John.

"I know he ain't! But you've got the wrong angle. Don't put yourself in his class. You're a good engineer. Make the plant show it!

"If he puts obstacles in your way and won't listen to reason, get out. Get another job.

"If you're big enough to do that instead of trying to get square by ill treating the plant, you're big enough for a bigger job."

With this John Operating Engineer walked out of the room, while John Operating Engineer watched him from his chair, already convinced that he would get that bigger job.

Power Plant of Chester Valley Electric Co.

By Warren O. Rogers

SYNOPSIS—A good example of a small central station, carrying a mixed electrical load. High-pressure superheat boilers and steam turbines have taken the place of saturated-steam boilers and reciprocating engine. The condensers serving the turbines are in a concrete pit in the basement.

A great deal of attention has been given to the description of large power plants, the majority of which have been turbine installations. This type of power plant has become what might be called standard design, and is so familiar to engineers as to perhaps give the impression that turbines are not used in small power plants.

Contrary to this possible supposition there are a large number of small installations which are giving efficient and dependable service. As an instance of a small turbine proposition, the plant of the Chester Valley Electric Co., Coatesville, Penn., is taken as a typical installation. The output of the station is used for lighting, motor circuit and for street-railway service. Like many other similar power plants the equipment comprises old and new units in both the engine and boiler rooms. The original unit in the engine room was a 500-hp. side-crank engine, directly coupled to a 525-volt generator, running at a speed of 150 r.p.m. This engine was piped to four 125-hp. water-tube boilers.

This station has placed in reserve the old boilers and the reciprocating engine and uses in their stead two 400-hp. water-tube boilers and two steam-turbine sets. One turbine drives a 625-kv.-a. alternating-current generator, the other a 940-kv.-a. generator, both three-phase, 60-cycle, 2400-volt, running at 3600 r.p.m. Both turbines, Fig. 1, are operated in conjunction with two surface condensers which are equipped with an 8-in. circulating pump and No. 14 Rotrex air pumps, both engine driven. The condensers are in a concrete-lined pit, Fig. 2, below the engine-room floor.

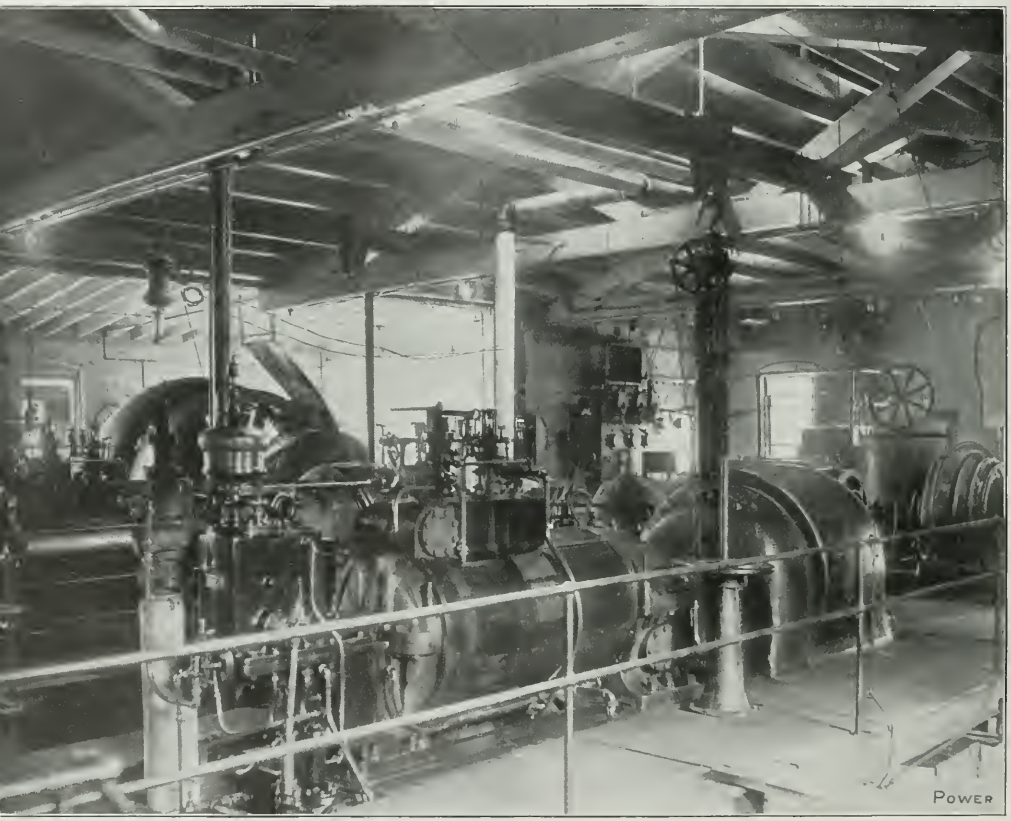


Fig. 1. View of the Turbine Room

Circulating water for the condensers is cooled by being discharged to a water-cooling tower out in the yard, as shown in Fig. 3. The discharging water flows over baffle

slats and in dropping from one to the other is cooled. The water finally reaches the reservoir beneath the cooling tower and is again circulated through the condensers.

The cooling water goes to the tower at 100 deg. F. and

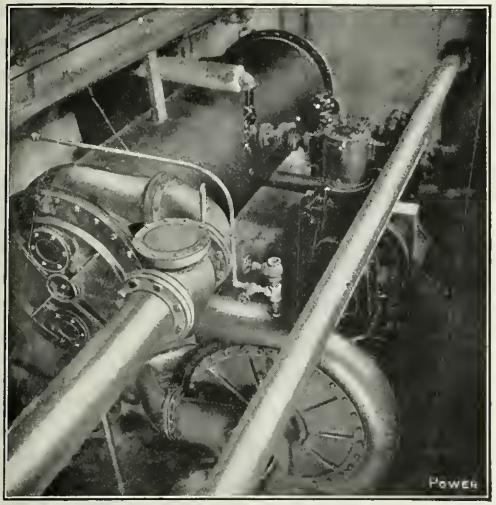


FIG. 2. CONDENSER IN CONCRETE PIT

has a temperature of 80 deg. F. in the storage tank from where it is taken by the circulating pump.

BOILER ROOM

Of the six water-tube boilers, but two are used, with the turbines. A view of the boiler room is shown in Fig.

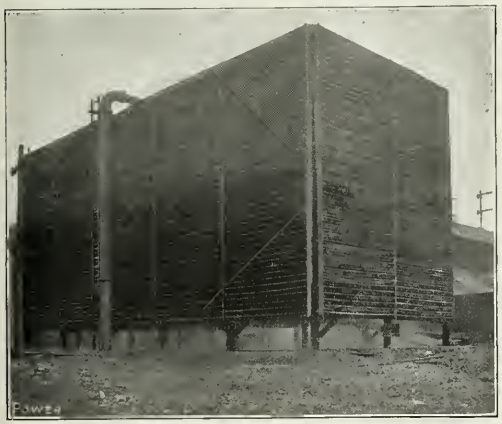


FIG. 3. WATER-COOLING TOWER

4. But one boiler and turbine are used during the day run. The boilers are piped to one main 18-in. header run above the boilers. In the turbine room the header drops to the basement to an 18-in. cross-header from which branch pipes lead to the two turbines.

Coal is delivered from coal cars on a spur track to an outside storage bin under the track trestle. It is then wheeled into the boiler room convenient for the firemen.

Feed water is handled by an open heater and either of two 10 and 6 by 10-in. outside-packed duplex pumps. These are placed in the boiler room between the batteries of boilers.

ELECTRICAL EQUIPMENT

Besides the main generators there is a 200-kw. rotary converter, three-phase, 60-cycle on the alternating side, and 600 volts of direct current. The shaft of this unit is extended, upon which a 35-kw., 550-volt direct-current generator is mounted and used for street-car and motor service.

The exciter unit is a 35-kw., 125-volt direct-current generator driven by a steam turbine at 3500 r.p.m. It is placed near the end of the turbines. A second exciter unit consists of a 30-hp., 2200-volt, three-phase, 60-cycle,

FIG. 4. PARTIAL VIEW OF THE BOILER ROOM

induction motor directly connected to a 125-volt, direct-current generator at 1130 r.p.m. The turbine exciter unit is used and the exhaust steam sent to the heater to heat the feed water, as is also the exhaust steam from the boiler-feed pumps.

Another motor-driven set is used for motor service, when run. The 75-hp. induction motor uses three-phase, 60-cycle current at 2300 volts and is directly connected to a 35-kw., 550-volt, direct-current generator driving it at 1175 r.p.m.

The switchboard, transformer, mercury rectifier, etc., are all placed at one end of the plant. The entrance to the plant, which is built of brick, is through the engineer's office, which is at one corner of the engine room. The chimney is of common brick and is built separate from the building. The form of record sheet kept at the plant is shown in Fig. 5.

It is simple and yet gives ample opportunity to record sufficient data to enable the engineers to know what the plant is doing from week to week. Running readings are taken every hour, showing the steam pressure carried, the vacuum maintained and the kilowatt-hour output

of the plant. The temperature of the feed water entering and leaving the heater is recorded, also the discharge temperature from the condenser.

Down the side of the record sheet are headings under which data regarding the electrical output for various circuits, weather conditions and hours the various units are in operation are recorded.

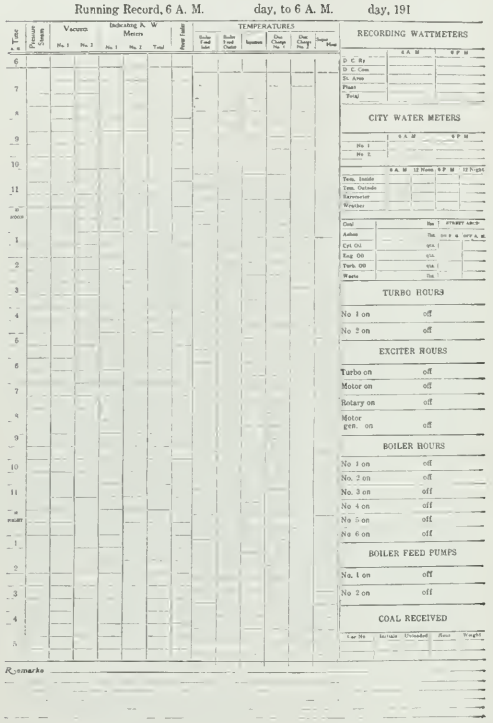


Fig. 5. Report Sheet of Plant Operation

Although this power plant is small when compared with others, it is a good example of what can be done with a small central station carrying a mixed electrical load.

Jefferson Flexible Union

A new flexible union has been designed to use with pressures up to 250 lb. and over. The most important point about this type of union is that if the pipes are out of line the unions can be used as readily as if they were in line.

This union has all of the regular features of all other kinds made by the Jefferson Union Co., Lexington, Mass. The shoulder on the nut and swivel end is made spherical and concentric with the ground ball joint, and the swivel end is allowed sufficient play in the nut, so that at any angle less than 5 per cent. the union may be made tight.

❖

Sarco Smoke Recorder

This device was described on page 1493, Aug. 16, 1910, issue and was known at that time as the Wattles smoke register. Since being taken over by the Sarco Engineering Co., 116 Broad St., New York City, no material changes have been made with the exception of the chart, illustrated herewith, which records a wider exposure of the smoke density on a sensitive paper chart than formerly.

Chart from Sarco Smoke Recorder

PRINCIPAL EQUIPMENT OF THE POWER PLANT OF THE CHESTER VALLEY ELECTRIC CO.

No.	Equipment	Type	Capacity	Size	Operating Conditions	Manufacturers
1	Main engine	Corliss	500 hp.	24x36"	150 r.p.m., 150 lb. steam	Clark Bros. Co.
1	Main generator	Direct current	525 volts, 696 amp.		150 r.p.m.	General Electric Co.
4	Steam boilers	Water tube	125 hp.		125 lb. steam	E. Keeler Co.
2	Steam boilers	Water tube	400 hp.	4067 sq.ft	150 lb. steam, 100 deg. super.	Heine Safety Boiler Co.
2	Superheaters	Double box			100 deg. superheat	Heine Safety Boiler Co.
2	Furnace Grates	Shaking				Washburn & Granger
1	Steam turbine	Horizontal	625 k.v.a.		3,600 r.p.m., 150 lb. steam	Westinghouse Machine Co.
1	Steam turbine	Horizontal	940 k.v.a.		3,600 r.p.m., 150 lb. steam	Westinghouse Machine Co.
1	Turbo-generator	Alt. current	625 k.v.a., 2,400 volt.		3-phase, 60-cycle, 3,600 r.p.r	Westinghouse Elec. & Mfg. Co
1	Turbo-generator	Alt. current	940 k.v.a., 2,400 volt.		3-phase, 60 cycle, 3,600 r.p.r	Westinghouse Elec. & Mfg. Co.
2	Condensers	Surface			28-in. vacuum	C. H. Wheeler Mfg. Co.
1	Cooling tower	Gravity				C. H. Wheeler Mfg. Co.
1	Feedwater heater	Open			210 deg. F.	Harrison Safety Boiler Works
2	Boiler feed pumps	Duplex		10x6x10 in.		Buffalo Steam Pump Co.
1	Rotary converter	Alt. and d.c.	200 kw., 600 d.c. vts.		3-phase, 60-cycle, 1,200 r.p.m.	Westinghouse Electric & Mfg. Co.
1	Generator	Direct current	35 kw., 550 volts.		Driven by converter unit	Westinghouse Electric & Mfg. Co.
1	Generator exciter	Direct current	35 kw., 125 volts.		Turbine driven, 3,500 r.p.m.	Westinghouse Electric & Mfg. Co.
1	Steam turbine	Single stage	35 kw.		150 steam, 3,500 r.p.m.	Westinghouse Machine Co.
1	Motor	Induction	30 hp., 2,200 volts.		3-phase, 60-cycle, 1,130 r.p.m.	Westinghouse Electric & Mfg. Co.
1	Exciter generator	Direct current	20 kw., 125 volts.		Motor driven, 1,130 r.p.m.	Westinghouse Electric & Mfg. Co.
1	Motor	Induction	75 hp., 2,300 volts.		3 phase, 60-cycle, 1,175 r.p.m.	Triumph Electric Co.
1	Generator	Direct current	35 kw., 550 volts.		Motor driven, 1,175 r.p.m.	Westinghouse Electric & Mfg. Co.

The Venturi Steam Meter

By Charles G. Richardson

SYNOPSIS—An explanation of the construction and operation of the venturi meter when used for measuring the flow of steam through a steam pipe. The rate of steam flow is indicated on a dial in pounds per hour at the moment of observation. A recording-chart dial furnishes an unbroken record of the rate of flow from hour to hour through the meter tube. A counter dial shows the total pounds of steam which have passed through the meter tube.

Twenty-six years ago, when the venturi meter was invented by Clemens Herschel, it was recognized that the same laws which were found to govern the flow of water through a venturi tube should apply equally well to gases. At that time, however, the demand for an accurate meter

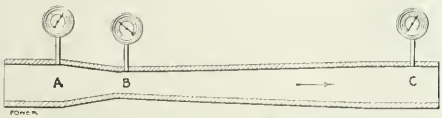


Fig. 1. Outline of Meter Tube

for water supplied towns and cities through main pipe lines was preëminent and attention was concentrated upon the development of the venturi for such service.

In order to know whether a battery of boilers is performing its duty the amount of coal burned and water evaporated must be compared. Consequently, boiler tests have become more frequent than heretofore, but seldom are the results of such tests even approximately representative of daily operation. Nearly everyone concerned is eager at such time to make a good showing and thus the calibration is conducted under abnormally favorable conditions. Quoting the expert's figures, during a test the evaporation of pounds of water per pound of coal may be as high as 10, while under regular service the evaporation is frequently 5, averages 7 and rarely reaches 9 lb.

To meet the demand for a continuous check on the efficiency of steam production various types of coal weighers and water-measuring apparatus have been placed on the market. The venturi meter was early developed to measure boiler-feed water of high temperatures.

Many plants use large quantities of steam for manufacturing processes as well as for power. It, therefore, becomes highly important not only to know that the steam is being economically generated, but that an excessive loss is not taking place in the distribution to the various departments. Suspicion of such waste has little weight with department foremen as each points to the others as responsible, "if, indeed, there is any waste at all." Thus the investigator travels in a circle, arriving finally at the starting point, and is unable to prove his case. As a consequence, there has arisen a demand for a reliable steam meter, some of which indicate, by a pointer, the rate of steam in pounds per hour flowing at the moment of observation; others contain a chart upon which this rate is autographically recorded and from which the total pounds may be computed. Nearly all employ some form of a pitot tube projecting into th main pipe from which one or more small pressure pipe lead to the instrument.

It has been proved by a series of calibrations that th original ideas regarding the adaptability of the ventu meter for the measurement of gases were sound and is the purpose of this article to describe the commerci apparatus.

When steam flows through a pipe contracted, as show in Fig. 1, the pressure at the throat B is less than the inlet A, due to the increased velocity at B. In properly proportioned pipe this loss of pressure is almo entirely regained at the outlet C, which in turn is due t the decrease in velocity after the steam passes the throa These facts may be proved by inserting pressure gages a A, B and C.

Practically the same amount of steam, therefore, wi be delivered through such a tube as through a length straight pipe of equal length and diameter under th same working pressure. The temporary loss of pressu at B can be accurately measured by a U-tube containin mercury and the difference in pressure between A an B bears a definite relation at all times to the rate of flo or velocity, at B.

Meter Tube

The meter tube, Fig. 2, is made in several sectio bolted together by flanged joints. The size is expresse by the diameter of the ends in inches, thus an 8-in. met tube will properly fit into an 8-in. pipe line. Steam flow from left to right when the tube is in the position i lustrated. At A, Fig. 1, is an annular chamber enci cling the tube, called the inlet pressure chamber; at B is similar chamber called the throat pressure chambe Numerous vents open into the chambers from the i terior and connections to the indicating or registerin instrument are made at the tapped holes shown. Th

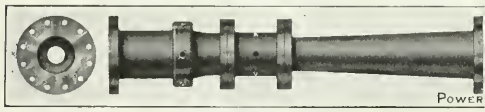
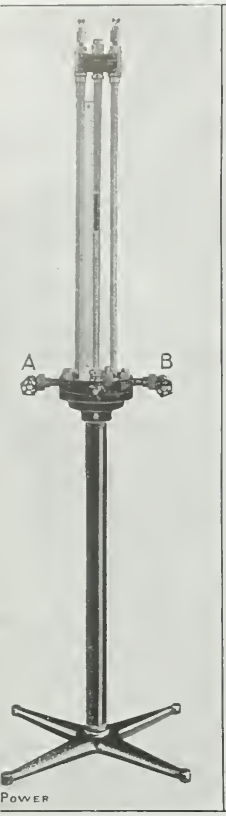


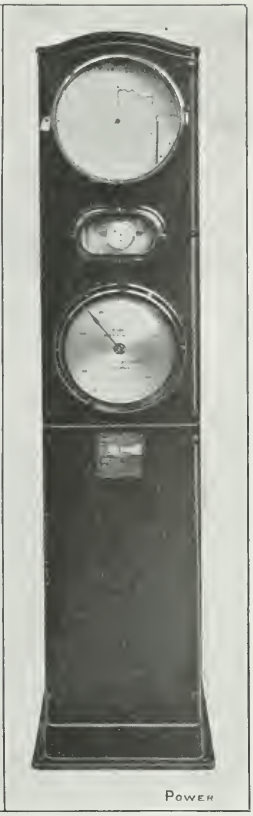
Fig. 2. Meter Tube

contour of the inside is similar to Fig. 1. The throat lined with bronze. Calculations for rate of flow a based upon the throat diameter. The end view, Fig. shows the entire absence of any inwardly projectin parts.

Manometer

Theoretically the simplest indicating instrument whic could be employed with the meter tube would be a U-tub one leg connecting with the inlet and the other with th throat pressure chamber of the former. Commercial the latest type of instrument is constructed, as illustrate by Fig. 3, on the principle of the barometer and consis essentially of a single glass tube projecting into a wo containing mercury. The upper portion of the well connected through the valve A to the inlet of the mete





g. 3. Manometer. Fig. 4. Type M Register-Indicator Recorder

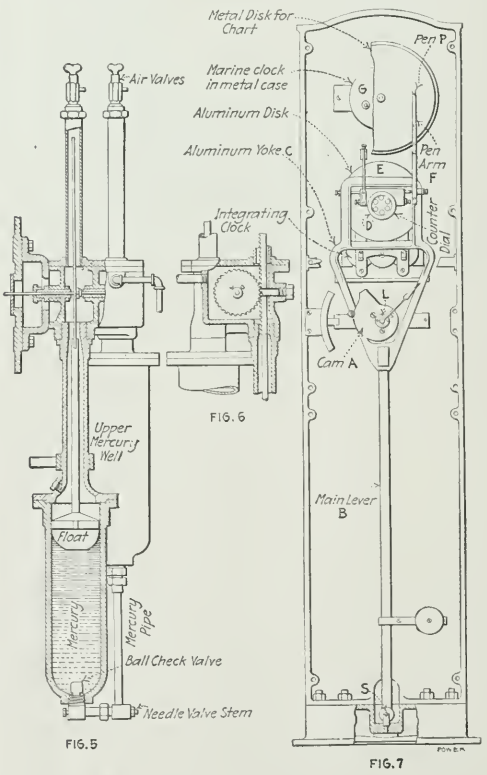
pe and the upper portion of the glass tube through the ve *B* to the throat of the meter tube. There is no flow water or steam through the manometer and it contains mechanism.

The rate of flow in pounds per hour, or other units, is d directly on the graduated scale shown at the left of glass tube. Before starting operations this scale is adjusted vertically that the zero line near the bottom nes opposite the top of the float resting on the mercury umn. No further setting is necessary when taking dings, the fixed scale forming a distinctive feature of s instrument. The rate of flow is read opposite the of the float, thus avoiding errors introduced in sim- instruments by the mercury meniscus. The total ntity of steam is equal to the product of the average e, obtained from periodic observations, and the elapsed ne. By employing separate scales a single manometer y be used alternately with any number of meter tubes. r an occasional determination of the amount of steam plied to the engine room and other departments of plant, a meter tube may be placed permanently in h main line and the manometer, which is portable, d in connection with any one of these tubes as often desired.

A new type of registering instrument, shown by Fig. 4, is called the Type M register-indicator recorder. This machine has three dials: the indicator dial shows the exact rate of flow in pounds per hour at the moment of observation. It is over 30 in. in circumference and can be read to ½ of 1 per cent. By observing the position of the dial hand the operating engineer can throttle the flow to any desired rate. If required an additional hand, which can be set to any graduation mark, is supplied so that by regulating the steam valve in such a manner as to keep the two hands in alignment a definite steam supply is continuously maintained. Irregular steam flow and defective action of steam-taking units are revealed by oscillation of the dial hand.

The chart-recorder dial contains a circular chart approximately 12 in. in diameter which furnishes an unbroken record of the rate of flow from hour to hour through the meter tube. These charts form a daily record of all irregularities in steam consumption, whether due to normal demands or inefficient operation. The counter dial shows the total pounds of steam which have passed through the meter tube and is similar to the dial of an ordinary water meter.

Fig. 5 shows a section through one of the two mercury wells at the rear of the register. The two wells are connected at the bottom by a small pipe. Each well is filled with mercury to the level shown, and upon each mercury surface rests a float. The lower well is subjected to the inlet and the upper to the throat pressure of the meter



Figs. 5, 6 and 7. Details of Registering Apparatus

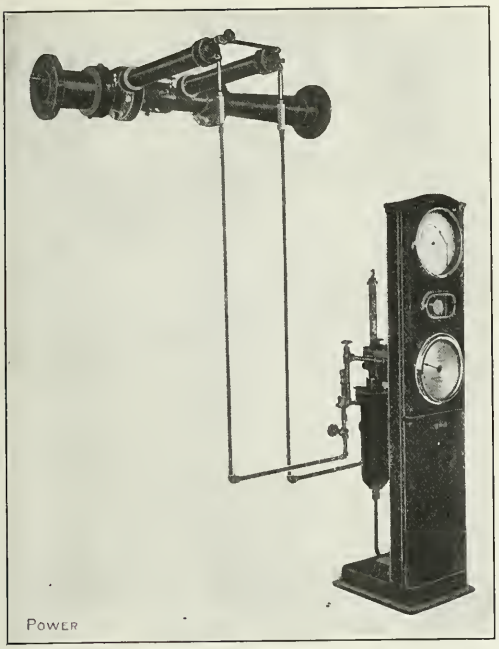


FIG. 8. METHOD OF INSTALLING METER

tube, so that a portion of the mercury is constantly being transferred from one well to the other in direct proportion to the difference in the two pressures. This causes one float to rise and the other to descend and such movement is transmitted through substantial rack and spur gearing to the main, or indicator-dial hand shaft, as illustrated by the sectional side view, Fig. 6.

The indicator-dial hand shaft *L* carries on its front end a cam *A*, Fig. 7. The cam controls the movements of a main lever *B* which is supported on two knife-edge bearings *S* and carries a yoke *C*. The counter dial *D* is actuated by a small roller which presses upon the aluminum disk *E* revolved at constant speed by a pendulum clock. The amount of movement of the counter-dial hands is therefore determined by the position of the roller on the disk. This particular type of integrating device was designed for use with earlier registering devices for water measurement. The aluminum yoke also carries pen arm *F* containing pen *P* which makes a continuous record of the rate of flow upon the circular chart revolved by a marine clock movement *G*.

In Fig. 8 is shown a typical arrangement of meter tube and registering instrument. Steam does not flow through the register; its readings are controlled by the difference in pressure at the inlet and throat of the meter tube as transmitted by the two small pipes. In each of these pressure pipes and close to the meter tube is placed a horizontal "condensing chamber" of simple construction, the purpose of which is to keep an equal head of water, or condensed steam, in both pressure pipes when variations in flow occur.

Fig. 9 illustrates an actual chart (reduced) obtained from a 3-in. meter in service in one of the power plants of a prominent electric-railway company. The steam was supplied to 14 fan blowers located under the boilers and which were automatically switched into or out of service by a single pressure-regulating valve controlled by the steam pressure in the main pipe. The irregular lines on the chart show the steam requirement when the blowers were running and also the frequency of operation. The regular lines *A*, *B* and *C* were made when the blowers were cut out, apparently recording a flow of steam amounting to 1400 lb. per hour. Actual investigation showed that the balanced controlling valve was leaking and could not be made tight. In other words, the venturi meter revealed a waste of steam amounting to approximately 34,000 lb. every 24 hours.

Among the more prominent advantages of the venturi steam meter the following claims are made:

The tube gives a very high difference in pressure between the inlet and throat, amounting to 10 lb. per sq.in. at the maximum capacity for which the meter is designed. Slight changes in rate of flow are consequently accompanied by comparatively large changes in differential pressure, allowing the registering device to be ruggedly constructed and avoiding all delicate parts or adjustments.

Steam flows only through the meter tube which contains a perfectly unobstructed passageway. Insertion of the meter tube in the main line does not, like an orifice, cause a drop in steam pressure.

The accuracy of operation of the registering device can be easily tested at any time by connecting the manometer into the two pressure lines shown by Fig. 8 and comparing the readings of the two instruments. The

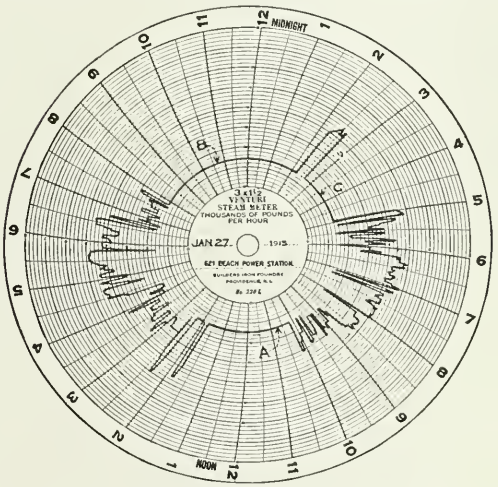


FIG. 9. A TYPICAL CHART

register furnishes three distinct kinds of information, each of which is of high value in improving and maintaining economical operation of the power plant. The meter has a wide range of capacity; thus an 8-in. meter will accurately measure all rates of flow between 8000 and 43,000 lb. per hour at 100 lb. gage pressure. It also automatically corrects for one-half the difference in density of steam for pressures other than for which the graduations are calculated.

Cooling Towers for the Power Plant

By Everard Brown

YNOPSIS—Types and construction of towers, distribution of water and air, and principles of operation.

Cooling towers have been in use commercially in this ountry for about twenty years. It is only within the ast few years, however, that they have met with any reat encouragement, and this has been due mostly to ie advent of the steam turbine, particularly the low-ressure type. In fact, it might almost be said that in iany localities where the quantity of water is limited, ie cooling tower has made the use of condensing ma-iinery possible. This fact is perhaps more greatly em-hasized in connection with exhaust or low-pressure team turbines which require high vacuums in order to et maximum output at minimum cost. There are, no oubt, many installations in existence today running con-ensing as a result of the cooling tower.

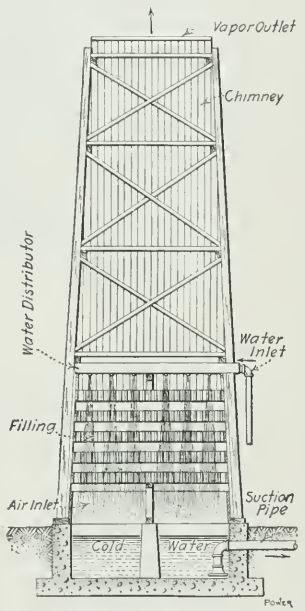
As a rule each installation of cooling towers must be reated separately because of climatic conditions; there-ore, no general formula can be laid down for towers of arying capacities that would be applicable to all locali-es. It might be stated in a general way, however, that ocalities best suited to their use are those possessing a ry climate. The two most potent factors that enter n to the proper design and size of an installation are emperature and humidity of the atmosphere.

The function of a cooling tower is to dissipate the eat in the ingoing water to the atmosphere and its gen-ral principles are to some extent the reverse from those mbodied in the condenser. Its efficiency, therefore, de-ends entirely upon the amount of heat extracted from ach pound of water at a minimum cost for fixed and perating charges, consequently its design and construc-on should be such that a most intimate contact will e obtained between the water and the air. The heat in ie water is extracted in two ways, namely: by supply-ng the latent heat for vaporization and by heating the ir passing through the tower. The first of these removes ie greater portion of the heat.

Water Vapor Absorbed by Air

The amount of water vapor which can be absorbed by ny given volume of air depends upon its temperature nd the amount of water present in the air originally. lso any increase in the temperature of the air naturally ncreases its water-absorbing capacity. The term, relative umidity, is the ratio of the water vapor in the air to ie water vapor it contains when saturated. Now, for xample, suppose that in a certain locality the average elative humidity is 72 per cent. and the average emperature is 52 deg., then the average weight of water er pound of air is approximately 0.006 lb. If the umidity is increased to 100 per cent. and the air is at ie same temperature, then the weight of water per pound f air is about 0.008 lb. Therefore, if a pound of this ir passes over water and becomes saturated it can take p 0.002 lb. of water in the form of vapor and thus educe the temperature of one pound of water approxi-nately 2 deg. In addition to this abstraction of 2 B.t.u., he increase in the temperature of the air as it rises in the tower gives it a larger vapor-absorbing capacity per unit of quantity so that its capacity would be about 0.044 lb. if it were heated, say, 100 deg., thus representing an abstraction of 2 deg. from approximately 19 lb. of water.

It can readily be seen, therefore, why a closed tower is more effective than an open one and that the hotter the water discharged by the condenser, the hotter will be the rising current of air, and, consequently, the greater will be its capacity for taking up moisture and abstracting heat. It is also evident that the less moisture there



General Design of Cooling Tower

is in the ingoing air the greater will be its absorbing powers, which accounts for the fact that cooling towers are more suitable for a dry than a wet climate. At many installations a large cloud of vapor may be noticed hovering over the tower, which might possibly be drawn down into it again and thus reduce its effectiveness. Under such circumstances it may be advisable to provide a reasonably high stack to carry off this vapor.

The air leaving the tower should, of course, be as nearly saturated as possible, and this can be accomplished only by getting the most intimate contact between it and the water. In order to get the best results from an economical viewpoint, there should also be a fixed relationship between the condenser and cooling tower as to temperatures as well as between the quantities of all air and water entering the tower. It is on these relationships that the proper design and size of the tower is based. For example, the manufacturer will guarantee a difference in temperatures between the ingoing and out-

going water of the tower of, say, 25 deg., or from 120 to 95 deg., at a certain wet-bulb temperature. This, however, does not mean that the same reduction of 25 deg. will result with water entering at 100 or 115 deg., even though all other conditions remain the same. The calculations in this case are all based on ingoing water at 120 deg., and the amount of cooling surface in the tower is governed accordingly. This means, that there are certain conditions upon which a cooling-tower guarantee of performance is based, namely: quantity of water handled, initial temperature of this water and wet-bulb temperature. The first two of these can be largely controlled, but the third is a variable that may change at any time. So, it is apparent that the conditions under which the guarantee is made are met with only at times and then only can the range of water temperature guaranteed be obtained. It might be interesting to note, however, that there are records of some installations where the temperature of the water has been lowered below that of the atmosphere. This, of course, is the result of the heat abstraction due to vaporization.

Types of Cooling Tower

Cooling towers are made in many different forms, such as round, square, rectangular, octagonal, etc., although the round and square ones are probably the most common. The shell is made either of wood or metal, usually at the option of the purchaser. A shell made of a good grade of swamp cypress will probably last as long if not longer than one of steel, especially if the wood is first treated with some good wood preservative. A steel shell should be well painted both before and after erection in order to protect it from corrosion. The wood is perhaps slightly cheaper and the steel requires somewhat less ground space, otherwise the advantages of the one over the other are practically negligible. The filling usually consists of boards or strips of swamp cypress, geometrically arranged so as to insure complete and ultimate distribution of the water and the air. The arrangement should also be such that there will be the least possible frictional resistance to the air circulation, thus reducing to a minimum the power required to operate the fans and at the same time permitting the flow of a larger volume of air through the tower, such as might be necessary in the case of a temporary overload. Perforated iron or steel mats, wire nets, tile or metal tubing, cloth, etc., are also used quite extensively for the same purpose. In all cases, however, the same precaution should be taken to get good distribution with as little resistance as possible because both of these are very essential to the best operation of the tower. Some objection has been raised to the mat or cloth filling because dirt and possibly oil from the cylinders of the engines are apt to clog up the small openings in the mats and cling to the surface of the cloth so that the water will not become so finely divided, but will descend in more or less large films or streams, which, of course, is inimical to high efficiency. To overcome this difficulty, at least to some extent, such fillings are so designed that the mats or cloth can be removed in sections for the purpose of cleaning without interrupting in any way the operation of the tower. All fillings, irrespective of design and material, should be self-supporting and practically independent of the shell.

Distribution of Water

Another important factor that must receive due consideration is the even distribution of the water at the top of the tower. There are several types of distributors for this purpose, all of which no doubt have, at least some merits. Of these various types there are two that seem to enjoy the greatest popularity. One of these is simply a flume on the side of the tower which feeds a number of small troughs that are laid across the top of the filling. These troughs are perforated with many comparatively small holes and if there are a sufficient number of troughs, a pretty even distribution may be expected. The other method of distributing the water is by means of a revolving hub to which a number of pieces of pipe are radially attached in a way similar to the spokes of a wheel. These pipes or spokes are perforated along one side only so that when the water is introduced it causes a revolving action due to the force of the jets from each of the perforations. The apparatus is simply a large lawn sprinkler that throws the water out radially instead of upward. Because of its shape and revolving motion it is best suited to round towers.

Air Supply

A forced-draft tower, as its name implies, depends upon one or more large fans, generally located near the base to create the draft. It should be fully enclosed around the bottom with the exception of the fan openings so that the only egress for the air is up through the filling and out of the top of the tower. This type does not require a stack unless it be for the purpose of carrying off the vapors so that they cannot be again drawn in by the fans at the bottom. There is another type of forced draft tower in which a single fan is located horizontally at the top of the tower which draws the air in at the bottom, up through the tower and then forces it through a short stack which, with such a construction, is essential. In this case there is an open space all around the bottom of the tower to admit the air freely. Usually the shell and filling are supported on deep steel or concrete girders that extend across the rest on the walls of the sump, thus leaving an opening all around equal in height to the depth of these girders. This horizontal type of fan is usually driven by means of a pelton wheel, also located horizontally, at the top and just beside the fan. Both the fan and the pelton wheel driving it are supported by an hydraulic step bearing. A design of this kind has the advantage that it requires nothing but water for its entire operation, whereas the other type with the vertical fans at the base usually have motors to operate the fans. It is questionable, however, whether there is any saving in power with the single fan at the top over the regular motor-driven fans, as the water to operate it must be pumped to a considerable height. It is also questionable if as good a distribution of the air is obtained. The actual amount of power required to operate fans for either type, depends upon too many variables that govern the quantity of air required in order to get the most economical results to permit of any standard rule or even much of a predetermination for any particular installation. Calculations should, of course, be made in order to determine as nearly as possible the size of drive required, but they can only be made for the individual installation under consideration.

The natural-draft tower is similar to the forced-draft except that a relatively high stack is required and that plenty of space must be allowed for the air to enter at the bottom. Not having any fans, it is naturally a less expensive installation both as to initial and operating costs. A larger cooling surface is necessary, however, which means that more ground space is used as it is hardly advisable to build the structure very high on account of the large head against which the water must be pumped. Its operation will be more variable than with the forced-draft type, because of its dependence only upon the natural rising action of the heated air for its draft, consequently, when the weather is not favorable, the results in the tower will be likewise. Europe seems to be quite partial to this type of tower, due, perhaps, to its low initial cost and freedom from much care and attendance, while in this country the reverse seems to obtain, the idea being to get the maximum results possible under all weather conditions even at an increased expenditure of money, if necessary.

Homemade Tower

To all appearances a cooling tower is quite a simple affair, which fact has led many to erect a so called "homemade tower." Usually the results obtained, however, are not very satisfactory. While there is really no valid reason why such installations should not answer the purpose, yet they do not seem to come up to expectations, probably because the problem looked so easy that sufficient care was not exercised in the design. There are, of course, many patents covering certain forms of construction which prohibit their use without permission, and many of these have been thoroughly demonstrated and shown to properly perform the function required of them. Furthermore a great deal of time and money have been expended by cooling-tower manufacturers in perfecting their product, of which the builder of a homemade tower would get no benefit. It is also questionable whether there would be any great money saving in the end.

Four Essentials in Design

To insure a high profit upon the investment, the design of a cooling tower must comply with four essentials and these are: low initial cost, low operating cost, large cooling capacity and cooling range, and small ground area.

The fourth item is important only when the tower is to be placed upon a roof or where the ground area is limited or expensive. If these essentials are carefully borne in mind when designing the tower there is but slight possibility of failure even with a homemade one.

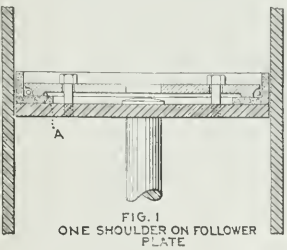
Pneumatic Cylinder-Packing Leathers

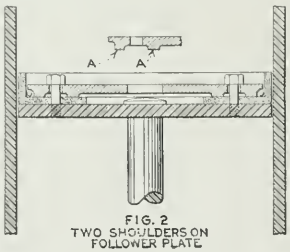
By F. W. Bentley, Jr.

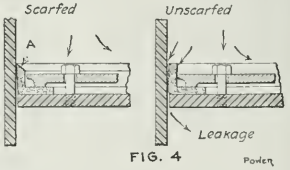
SYNOPSIS—Directions are given for replacing pneumatic cylinder packing, showing defects resulting from some methods employed and how to eliminate them.

Ever since compressed air has been used to operate hoists, brakes and other labor-saving devices, the general utility of leather for a cylinder packing in connection with them has never lessened. The soft pliable nature of leather and its great fibrous strength enable it to effectively retain compressed air. But leather does not completely cover the requirements of a cylinder packing when used for compressed air, and in many instances but little attention is given to the manner in which the leather is prepared and applied to the piston and cylinder. This, nevertheless, has a more direct bearing on the life and utility of the leather than almost any other condition imposed upon it.

Putting in a new cylinder leather does not require extraordinary mechanical ability, but when viewed from the standpoint of durability and service, as much care should be given to this work as to the repair of the most costly machinery in the engine room. The aim of this article is to bring out a few points, sometimes not considered, which directly tend to maintain the leather in perfect and efficient working condition as long as possible.







Details of Follower Plates and Packing Leathers

A packing leather is generally secured to the head of the cylinder piston by variously constructed follower plates. The most common type of follower is that shown by the cross-section, Fig. 1. The circular shoulder *A*, on the under side of the plate, is to force the leather tightly against the top of the piston head to form an air-tight union between it and the plate. The fault of this plate is its weakness, when made of cast iron, for the slight

leverage caused by the draw of the bolt inside the circular shoulder is often sufficient to break the follower.

This difficulty, in spite of the inherent brittleness of cast iron, can be overcome by using a follower having two circular bosses, allowing the follower studs to go through the plate between them, as *A*, Fig. 2. The compressive draw of the stud nuts is evenly distributed between the two bosses. Its construction necessitates using a wider leather, which is an advantage, as the leather is necessarily cut and fitted over the plate studs and cannot work out from the follower when tightened.

The packing leather, however, is the vital part of any pneumatic device possessing an air cylinder, and there are a few points in connection with the preparation of the leather, and its application to the piston head which, if heeded, will tend to greatly increase the efficiency of the leather. The commercial leather most commonly used for air-cylinder packing generally has one side of the material finished, which hardens its surface and destroys the porosity of the leather. The side known as the flesh side is porous and should come in contact with the cylinder walls, as it is pliable and can readily fill any irregularity or slight cut in the cylinder. The flesh side of the leather will more readily absorb and retain any lubricant put into the cylinder to prevent the wear of the leather and to assist in maintaining its pliability.

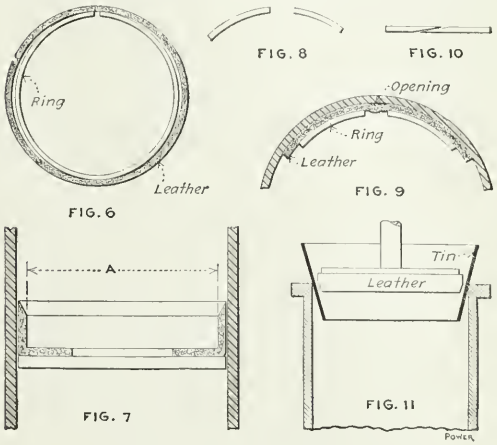
In many instances the packing leather is fastened to the piston head and drawn into the cylinder with no provision made to overcome cramping, for compression, as a result of forcing it into the cylinder, will cause parts of the leather to bend over and away from the cylinder walls. The rigidity of these parts in this position makes it difficult for even a very strong air pressure to force the leather against the cylinder and air leakage results.

FIG. 5. SCARFING A LEATHER

This difficulty can be overcome by scarfing the upper inner side of the leather to a thin edge, Fig. 3, and at *A*, Fig. 4. The air can then more easily force the leather against the walls of the cylinder and make the packing air-tight. The arrows, Fig. 4, also show the action of the air on the thick edge of an unscarfed leather, and how the thin edge of a scarfed leather is more easily thrown against the sides of the cylinder.

In Fig. 5 the edge of the leather is illustrated, held even with the side of some metallic surface and scarfed by turning the leather at each draw of the knife. The required angle of the scarf is easily kept during the cut by pressing the knife blade against the edge of the surface on which the leather is held.

Expander rings should be given special attention. Often these rings are rolled and set with too large an outside diameter, and then forced to enter the inside of the upturned part of the leather by cutting a piece off the ends. This is radically wrong, for it produces an elliptical-shaped ring which bears upon the leather at two points only, namely, at the ring opening and directly across from it at the swell of the circle. The leather consequently wears more quickly at these points and the rest of it



CONSTRUCTION OF EXPANDING RINGS

has only a slight contact with the cylinder walls. Fig. 6 is an exaggerated view to make this clear. The ring should be rolled to an outside diameter only a trifle larger than the inside diameter of the upturned part of the leather, as shown at *A*, Fig. 7.

Another important point in connection with the construction of the expander ring is the nature of the break or opening in the ring itself. Frequently the two ends of the ring are cut squarely across, as in Fig. 8. Should the diameter of the ring be a trifle too large or should the ring happen to have an undue amount of spring and an excessive opening, a part of the leather would not press against the walls of the cylinder, Fig. 9.

The most desirable and practical way to prepare the opening of the ring is to scarf the ends, allowing them to overlap. This can be done before the extra stock on the ends is removed after rolling, as in Fig. 10. This permits the expander to come in contact with the leather and press it outward at every point.

Often in hoists of the upward-pull type, due to their construction, the leather cannot be drawn into the cylinder, but must be compressed or forced into the mouth of the cylinder barrel. Fig. 11 shows how a rectangular piece of tin or sheet metal can be placed around the inside mouth of the cylinder, something after the style of a funnel. The piston head with the attached leather is then drifted into the cylinder. The leather cannot squeeze out at any point as it often does when the attempt is made to start or drift it with thin-edged chisels. The tin is easily withdrawn with a pair of knurled tip pliers, should it drift into the cylinder with the leather.

Standardization of Boiler-Stoker Installations*

By Joseph G. Worker

This paper has been prepared as a plea for the standardization of a better practice in the installation of boilers and stokers. This higher standard must be attained so that a practice may be established in the different cities that will conduce to a more smokeless operation of plants, independent of any boiler or stoker.

Today the people to blame for the smoke nuisance are the manufacturers of boilers and stokers, the purchaser who buys and operates the equipment, the consulting engineers and architects, the smoke inspectors. It cannot be stated that any one is more responsible than another. It makes no difference whether or not the boiler and stoker manufacturers present a smokeless combination, the installation can be ruined, insofar as the abatement of smoke is concerned, by the purchaser and operator. In order to correctly place the responsibility, it is necessary to analyze each installation separately.

There have been some improvements in recent years in the matter of boiler and stoker combinations. Boilers have been raised somewhat; stokers have been set differently; more attention has been given to the breeching design and higher stacks are being used. Still there has never been anything like the thought on this subject that there should be and the standardization of the practice that is necessary. There is need of an analysis of installations and the information should be translated into good data that can be distributed with confidence.

When a stoker is installed in combination with a boiler, there are many things that must be considered and decided jointly by the purchaser, the boiler and stoker manufacturer and the smoke inspector.

Height of the boiler header above the floor line or height of boiler setting, setting of the stoker, combustion space necessary for the coal to be used, design and location of the breeching, size and location of the stack, area of gas passages through the boiler, area of damper openings, facilities for cleaning soot off of boiler baffles and boiler tubes.

Other things that should be considered as affecting the reliability of the equipment are:

Grade of firebrick to be used in the furnace construction, size of walls of boiler and furnace setting, size and grade of firebrick for arches, if used; method used to control dampers, construction of ashpit and facilities for disposing of the ash, method of conveying coal to the stoker hoppers.

Referring to the foregoing items, if the purchaser failed to install the height of stack that was necessary, he would be the one that was responsible for the installation's failure. If the stoker manufacturer did not insist upon correct setting of the stoker, he would be responsible. If the boiler manufacturer failed to provide the correct areas for the passage of the furnace gases and arrange to set the boiler at a height required for the particular stoker selected, he would be responsible.

One frequently hears that boilers cannot be set higher because the contract for the masonry work has been included with the boilers; or, that the contract has already been let and the purchaser will not pay the extra cost of properly setting the boilers with the stoker selected. Again, we frequently hear that the boilers cannot be set right because the architect has previously provided so much room for the boiler and stoker and they must go within the limit provided whether a good or bad combination is obtained.

There is another phase of this problem that seems at the present to interfere with obtaining good installations, that is, the cost of the installation. Of course, boilers being raised, stokers extended, higher stacks, etc., cost more money. The boiler and stoker manufacturers and the smoke inspectors should, however, take a sufficiently firm stand for the combinations that are known to be right and be sure that enough money is expended to make them right.

What is needed is an organization that has for its object the diffusion of information and data on installations made to burn bituminous coal without smoke. Committees should be appointed to investigate and analyze installations of all kinds in all territories. For example—a committee consisting of members who live in the vicinity of Cleveland could take four or five different kinds of combinations in that locality from the time that they are installed and report to the organization everything that entered into the construction and design. Drawings and data could be presented that would determine what the particular installation would do in the abatement of smoke. The time has not come when a combination can be standardized in the West and be adapted to the conditions in the East, or *vice versa*, with success. There should be, however, one society from which all the data would emanate.

After the boiler and stoker have been selected, it is not yet time to finally decide whether or not these particular types should be purchased—it is not the time to sign the contracts. The purchaser should arrange a conference between the manufacturer of the boiler, the manufacturer of the stoker, the smoke inspector, if there is one, and himself. The whole combination and the things mentioned in the forepart of this paper should be discussed in detail and a decision made on each matter. The purchaser should not obtain an opinion from the boiler manufacturer as to how the boiler should be set unless he gives the stoker manufacturer an opportunity to present his opinions. If all points are settled on a good engineering basis, the best combination known will be obtained and the customer can well afford to expend the money necessary for it.

[Editorial reference to this paper is made on page 511 of this issue.—Editor.]

*Read before the International Association for Prevention of Smoke at its 8th annual convention, Pittsburgh, Penn., Sept. 9-12, 1913.

Power Generation and Hydraulicking are accomplished with the same water at the Pioneer tin mine in Tasmania. The powerhouse is situated 300 ft. above the mine and generates electric current by the means of impulse turbines operating under a head of 189 lb. per sq.in. During the six months ended Dec. 31, 1912, the mean power load was 482 kw. The power is transmitted at 6500 volts to the mine, and the water after leaving the turbines is conveyed 4¼ m. to a point 240 ft. above the mine, where it is available for use in the pipe lines to the hydraulicking giants.

ELECTRICAL DEPARTMENT

The Tirrell Regulator

By John A. Randolph

On all distribution systems, whether supplied by direct or alternating current, it is of vital importance that the voltage be maintained constant. There are several reasons for this: First, it has been found that the life of incandescent lamps is materially shortened by a fluctuating voltage, especially if it has a tendency to rise higher than normal; this renders lamp renewals more frequent. Moreover, an unsteady or variable pressure causes a variation in the intensity of illumination which is likely to result in dissatisfaction upon the part of the consumer. If the potential assumes values below normal for appreciable intervals of time, a loss in revenue to the station will ensue, owing to a decrease in the number of watt-hours supplied. Another disadvantage arises from the variation in speed and torque of motors suppplied by the system. This condition temporarily affects their efficiency and produces unsatisfactory results in the operation of the appliances to which they are attached. In view of the foregoing disadvantages and many others, careful attention is given to the maintenance of a constant voltage on all uptodate light and power systems.

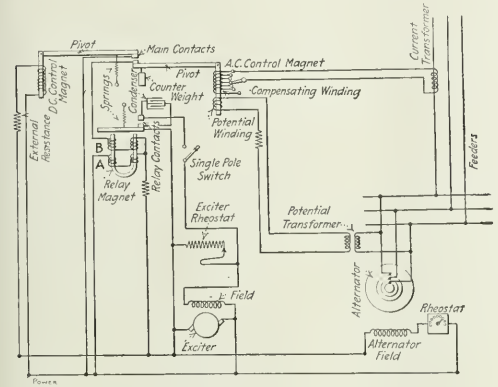


Fig. 1. Connections for Three-Phase Circuit

Various methods are employed for regulating potential. One of these consists in the adjustment of the pressure on the indivdual feeders. In another method, the regulation is effected at the generator. The latter practice is in most general use.

There are several means used in regulating generator voltage. The nature of these depends primarily upon whether the machine is of the alternating- or direct-current type.

The potential of alternating-current generators is regulated in various ways, the choice depending largely upon the capacity of the generator, the number of other machines in the station, the facilities for excitation and the method of drive, that is, whether by belt or direct connection. The methods most commonly used in this country consist of separate excitation, composite excitation and by an automatic regulator. In the first method, the voltage is maintained constant by varying the alternator field current with rheostats placed in both the exciter and main field circuits. The rheostats are also used in the composite method but, in addition, a part of the current from the alternator armature is rectified and sent through a compounding coil on the generator field. This produces a compensating effect which varies in conformity with the loads on the machine. The third method employs an automatic regulator, the leading form of which will be described presently.

On direct-current machines, the regulation is effected by rheostat control, compounding, and by devices that regulate the field current in the generator or exciter automatically.

Where the control is by hand, there is a disadvantage in that time is required of the attendant which could otherwise be devoted to other duties. Moreover, the steadiness of the voltage is to a certain extent dependent upon the personal watchfulness of the operator. Therefore, to eliminate the personal element and to produce a steadier voltage, the automatic regulator was devised.

Use on Alternating-Current Systems

There are several automatic devices in use for alternating-current potential regulation, but the one which has given the most general satisfaction is the Tirrell regulator. This device accomplishes its result by short-circuiting the field rheostat of the exciter when the voltage of the alternator is too low and opening the short-circuit again when the potential has risen sufficiently. So rapidly is this done that no appreciable fluctuations in the pressure are noticeable.

The device, as fundamentally constructed for alternating-current work, consists of two solenoid magnets and a relay as shown in Fig. 1. One of the magnets is operated purely by direct current and is connected through an external resistance directly across the exciter busbars. The core is free to move and actuates a lever carrying at one end a contact. The other solenoid is excited by alternating current and contains two windings, one of which is connected across two of the generator mains by means of a potential transformer. The other winding compensates for variable currents and is connected to a current transformer carried on one leg of the circuit. This solenoid, like the other, actuates a lever with a contact.

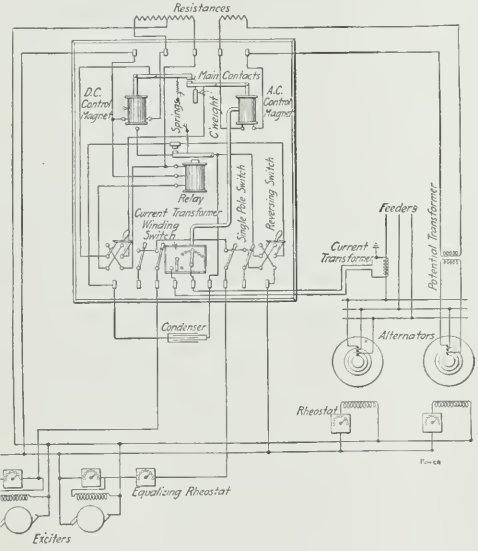
The relay consists of a U-shaped stationary iron core carrying two opposing windings A and B, and a movable armature actuating two contacts; the windings receive direct current from the exciter busbars. The current in coil A is continuous, but that in coil B, controlled by the main contacts, is intermittent. The relay contacts are so connected across the exciter rheostat that the latter is completely short-circuited when the contacts are closed.

he condenser is for reducing the arcing at the relay ntacts.

Operation

When placing the regulator in operation, the single-le switch in the rheostat short-circuiting lead is opened. he rheostat resistance is then turned into the exciter eld circuit until the voltage of the alternator is reduced bout 65 per cent. below normal. The lowered potential the exciter weakens the magnetic effort exerted by the rect-current solenoid upon its plunger, with the result at it is overcome by the springs at the opposite end of e lever; the upper main contact is consequently pulled ownward. The attractive power of the alternating-cur-nt solenoid is likewise decreased, and its core falls and lows the lower main contact to rise until it meets the pper contact.

The closing of the main contacts energizes the relay il *B* whose field in turn neutralizes that of coil *A*, thus demagnetizing the relay and allowing the spring to draw e armature upward and close the relay contacts. The ngle-pole switch is now closed. This at once raises the ltage of the exciter inasmuch as the rheostat is short-rcuited, all regulating resistance being thereby removed om the field circuit. The increased pressure of the ex-ter acts directly upon the generator field, raising the



G. 2. Tirrell Regulator as Ordinarily Arranged on Alternating-Current Switchboard

ternating-current potential in consequence. When the ltage has reached the proper value, the two control agnets are sufficiently energized to overcome the resist-nces acting against them and accordingly open the main ntacts. This causes the circuit through relay coil *B* to pen. Coil *A* being now no longer opposed, energizes the lay core and attracts the armature downward, opening e relay contacts and temporarily removing the short-rcuit from the exciter field rheostat. The latter being ow cut into service, lowers the voltage until the two control magnets again close the main contacts and thereby raise the pressure. In practice, this cycle of operations takes place so rapidly that it is best described as a high rate of vibration upon the part of the contact elements. The resulting voltage is not necessarily constant, but is steady.

In Fig. 2 are shown the connections and relative locations of the component parts of the Tirrell regulator used in alternating-current work, as they exist in practice. It will be observed that the hand-operated switches are lo-

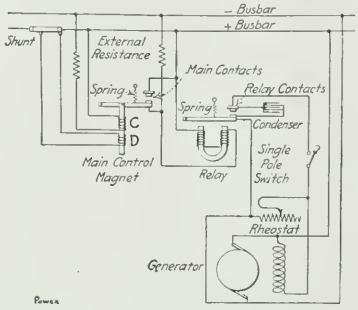


Fig. 3. Arrangement with Direct-Current Generator

cated in a convenient position at the bottom of the instrument. The connections here shown represent the method used where the instrument is employed for regulating the voltage on two or more generators operating in parallel, the exciters being also in parallel. By tracing the respective circuits it will be observed that the same general scheme of connections is used as is shown in the simplified diagram of Fig. 1. The double-pole, double-throw switches shown in Fig. 2 are for reversing the direct current in the circuits which they control. This is to furnish more flexibility in the handling of the instrument for testing and other conditions where a reversal of current may be required. The resistances shown at the top of the figure are contained in a well ventilated rectangular case located on the back of the switchboard panel and directly behind the regulator proper. The leads from the resistances to the regulator are connected to the latter through terminals at the top of the instrument, as shown. The other external connections are made through terminals at both the top and bottom of the instrument. The multiple-point switch shown at the bottom is for adjusting the number of active ampere-turns in the compensating or current-transformer winding of the alternating-current control magnet.

The automatic portions of the regulator are inclosed in a rectangular glass case, but the switches and terminals are left exposed for convenience in operation.

Use on Direct-Current System

The Tirrell regulator used for direct-current voltage regulation is similar in construction and operation to the form used with alternating currents. The fundamental diagram of connections is shown in Fig. 3. The main elements consist of a control magnet and a relay, the former having two opposing coils *C* and *D*. The winding *C* is connected through an external resistance across the main busbars, and the winding *D* is connected to an ad-

justable shunt carried either on one of the main busbars or on a feeder. The core of the magnet is movable and actuates a lever controlling two contacts. The relay has a U-shaped core with a winding connected through a resistance across the main busbars. By means of an iron-bar armature, it controls two make-and-break contacts in a circuit which, when closed, short-circuits the generator field rheostat. The arcing at the relay contacts is reduced by a condenser.

Operation of Direct-Current Regulator

The method of starting the direct-current regulator is very similar to that employed with the alternating-current instrument. The single-pole switch in the field rheostat short-circuiting lead is first opened, the resistance of the rheostat then being turned in until the voltage is brought to a value about 65 per cent. below normal. This weakens the excitation of the main control magnet to such a degree that the magnetic attraction on the plunger is overcome by the spring on the contact lever. The lever is consequently pulled upward, thereby forcing the main contacts together and shunting the relay winding. This causes the relay to lose its attractive force, with the result that its armature is pulled upward by its spring, the relay contacts being consequently closed. The single-pole switch is now closed. The rheostat now being completely short-circuited, the voltage at once rises because of the increased field excitation. With the rising potential an increasing current is caused to flow through the control-magnet winding *C*. When the pressure has reached the proper value, the main contact lever is drawn downward, opening the main control circuit. The relay is now energized, attracts its armature and thereby opens its contacts. The latter action places the field rheostat again in circuit, with the result that the voltage is lowered until the magnet and relay again cause it to rise. The opening and closing action of the contacts is vibratory and therefore maintains a steady voltage on the system.

The winding *D* on the main control magnet is for the purpose of delaying the action of winding *C* to an extent depending upon the current supplied by the generator. Heavy currents necessarily require a higher voltage at the busbars than those of lower value because of line drop. The voltage drop across the shunt in the main circuit varies with the strength of current, the result being that the action of winding *D* in opposing winding *C* is varied accordingly. The greater the excitation of winding *D* the longer will be the delay in the opening of the main contacts.

High-Tension Distribution by One-Wire Grounded System*

Single-wire transmission of electric current is one of the earliest forms of transmission and holds possibilities for securing rural business, due to its low cost. The Benton Harbor Co., studying along these lines, found that the only solution would be a grounded return primary distribution, giving single-phase current on a single wire and three-phase current on two wires. But as this would give a dead ground with the entire generating and transmission system, it became necessary to devise some means that would give immunity from grounds on the one hand and allow a permanent ground on the other. This can be accomplished very nicely by a 1:1 transformer, or if the rural lines are to be very long, a 1:2 transformation can be employed, giving a 4600-volt single-wire from a 2300-volt two-wire line.

About a year ago the company made arrangements to build such a line. Two commercial transformers with secondaries connected together, provided the necessary insulation between the rural and city lines. The single-wire line was built under adverse conditions, and is approximately 2.5 miles long. Triple-braided weather-proof wire has been used throughout the system both for primary and secondaries. The latter are not grounded in this system; in fact, all efforts possible were made to prevent the grounding. Lightning arresters are placed on the line at every transformer. Fuses are placed between the transformers and the ground and between the primary wire and ground. The grounded wire of the primary side is a No. 4 rubber-covered wire, which is nailed to the pole and covered with special wood mold in going to the ground and connecting with a 24-in. copper ground cone buried in moist earth with one sack of charcoal around the cone.

So far, the company is thoroughly satisfied and believes that on a properly constructed line on private right-of-way, thus getting away from heavy trees, a line can be built much cheaper than on the standard two-wire construction with less danger from high winds, sleet and other line troubles. A line of this character can be built for approximately $228 per mile as compared with $380 per mile where two wires are used.

*From a paper by John A. Cavanaugh, delivered at a recent meeting of the Michigan Section, National Electric Light Association.

Stator Not Properly Aligned

While employed several years ago as engineer in a steam-electric plant, one of our 1000-kw. engine-generators was so damaged by lightning coming in on the feeders as to make necessary the renewal of stator coils and shifting the stator to one side for access to the coils.

After repairs had been made, the stator was jacked back into position and bolted down; the engine was started, and the field current thrown on. Immediately a loud rasping or scraping noise was heard and the field current had to be taken off quickly, when the noise ceased.

Upon examination, it was found that the stator had been pulled over by the field current, causing the scraping noise. The erector had neglected to dowel the stator to its sole plate and since we could not seem to hold it in place, on account of the holding-down bolts not fitting, we left the jack and blocks in place, holding it by bracing from the engine-room wall. This answered for temporary use, until we could get the dowels in.

B. W. Dennis.

Columbus, Ohio.

Canadian Electric Transmission—Power will be delivered to the city of Windsor in the early spring if the present plans of the Hydro-electric Power Commission materialize, according to the Toronto "Globe." The right-of-way for the line from Chatham to St. Thomas has been selected. The line will run from Chatham to Ridgetown, and from there along the south side of the Pere Marquette Railway to St. Thomas. The St. Thomas to Windsor line will stretch over a distance of 112 miles.

GAS POWER DEPARTMENT

The Oil-Motor Industry in Italy*

The employment of large internal-combustion engines in Italy, which is now flourishing, hitherto depended for the most part upon imported machines. The manufacture of small high-speed benzine and petroleum motors has been successfully carried on by domestic shops for some years but as regards the building of heavy oil engines, Italy has just passed the experimental stage.

The first stationary Diesel engines of high power and Italian make were built by Franco Tosi, of Leghorn, who has recently been at work on marine engines of his own design. For five tank vessels under construction by the Esercizio Bacini Co.'s shipyard at Genoa, for the Royal Navy, three complete plants are being furnished by Tosi, and two by Fiat. This latter company, which formerly had built only large benzine motors for marine purposes has also been developing its own marine Diesel engines for submarines, an 850-hp. engine now being under construction for the German Imperial Navy.

The Italian Navy for years has been occupied with this question and has carried out a number of comparative tests, to determine a satisfactory type of engine for its submarines. Aside from submarines, the first experiment of the Navy with motor drive for war vessels was carried out this year upon two school ships, each equipped with a 1000-hp. Diesel engine, intended for the Naval Academy.

Nothing can yet be said as to the use of oil engines in the Italian merchant marine; aside from a few isolated experiments, attended with little success, the ship owners have not seriously taken up this matter. A few years ago, the Cantieri Riuniti built a motor freight vessel with Sulzer engines, and the Savoia Works an experimental vessel the "Savoia" with a 300-hp. oil engine, but the experience obtained has given little stimulus in the merchant marine.

The greatest opposing influence in the development of the oil motor has been the high import duty on oil, which in spite of the economic superiority of internal-combustion engines, has not allowed manufacturers and ship owners to realize their economic advantage.

Primarily, the interested parties are endeavoring to reduce the limit of specific gravity by which certain motor-fuel oils, such as the so called Italian "naftetine," now enjoy special concessions. The density limit of naf-

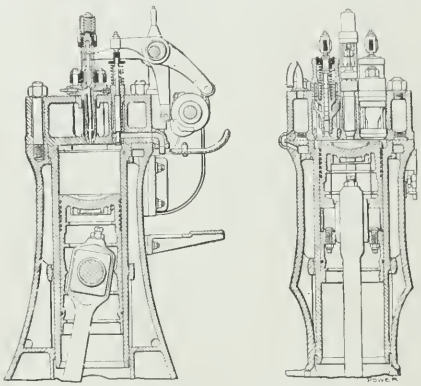


FIG. 1. SECTION THROUGH CYLINDER OF TOSI FOUR-STROKE-CYCLE ENGINE

*Translated and abstracted from an article in "Der Oelmotor," July, 1913.

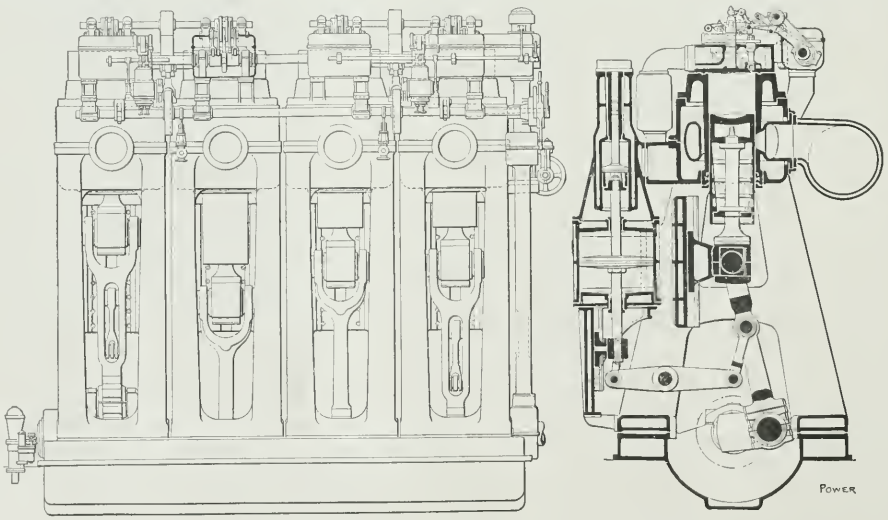


FIG. 2. TWO-STROKE-CYCLE TOSI MARINE ENGINE OF 500 HP.

tetine is, by the law of 1907, fixed at 0.925, and most of the motors built in Italy have proven unsuited for this.

Shops of Franco Tosi of Leghorn

The firm Franco Tosi, of Leghorn, is not only the largest, but the best organized machine-building works in Italy. It was founded in 1880 by Franco Tosi with 100 workmen, and today, under the leadership of his three sons, it employs some 2000 hands. The world-wide reputation which it has acquired in its comparatively short career is attributable primarily to the specialization of its manufacture, which comprises steam engines up to 5000 hp. (poppet-valve engines), steam turbines up to 20,000 hp., gas engines and oil engines of the Tosi-Diesel type. Following are the principal features of the Tosi oil motors:

Four-Stroke-Cycle Engines

The firm builds slow-speed and high-speed engines; the former range from 30 hp. per cylinder, and a speed of 210 r.p.m. up to 200 hp. per cylinder at 150 r.p.m. Units of this construction with four cylinders are made up to 800 hp. The high-speed engines are built from 15 hp. per cylinder and 350 r.p.m. up to 75 hp. and 300 r.p.m.

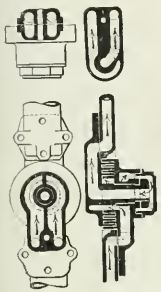


Fig. 3. Water Cooling of Tosi Engine

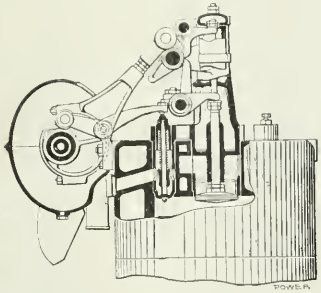


Fig. 4. Valve Details of Two-Stroke-Cycle Tosi Engine

The engines have very long plunger pistons, which for large cylinders are built in two parts. The piston rods and connecting-rods are of forged steel and have very broad bearings lined with white metal. The injection-valve rods are automatically lubricated, and large cylinders are provided, with water-cooled exhaust valves.

In the slow-speed type, the cylinders are cast separately from the box-pattern bed proper. The box bed of the high-speed engines consists of one casting on which the individual cylinders are built up. The compressor is of the multi-stage type and fills three receivers, one furnishing the air necessary for spraying the fuel, a second the starting air, and the third a reserve supply.

Two-Stroke-Cycle Engines

The two-stroke-cycle engines of the Tosi design are characterized by especially solid construction of the bed and base plate, by careful water cooling of all parts that come in contact with the hot gases and by the special design of the valve chamber with provision for expansion.

The upper connecting-rod journal is lubricated by a tube instead of through the connecting-rod itself, thus avoiding unnecessary throwing of the lubricating oil.

The commonest form of the Tosi two-stroke-cycle motors is the four- and six-cylinder crosshead type. Of these the firm has already built five of 1000 hp., running at 160 r.p.m., and three of 400 hp., the former for stationary plants, the latter for marine service.

By simply loosening the lower crosshead box and letting down the piston, the piston rings are very easily removed. A piston can also be taken out with facility without interfering with the lubricating system or removing the cylinder head.

Fig. 2 shows a 500-hp. two-stroke-cycle marine engine which runs at 170 r.p.m. As seen in the view at the right, the scavenging pumps are driven by links from two of the connecting-rods. The compressor is placed above these pumps.

By the separate arrangement of the scavenging pumps, these always handle clean and comparatively cool air, which contributes essentially to the useful power of the motor. Moreover, the independent position of these pumps permits driving them at a lower piston speed than that of the working pistons, thus lessening the air velocity in the passages and reducing harmful vibrations. This arrangement of the scavenging pumps distinguishes the Tosi engines from another Italian type, the Fiat. The latter has two-stage working pistons, the lower part of which serves as an air pump.

Fig. 4 shows a few details of the valves and Fig. 3 the water cooling of a Tosi two-stroke-cycle engine.

The Fiat Works, Turin

The first internal-combustion engines of the Diesel principle were finished by the Fiat firm in March, 1911. These were for driving the submarine "Medusa" and can be called the first Italian crude-oil engines. In a twelve-hour trial they developed at 452 r.p.m. 335 hp., with an oil consumption of 0.54 lb. per metric horsepower and fulfilled to the satisfaction of the Naval officials the conditions of burning the so called Italian "naftetine." This crude oil of Roumanian production has at 59 deg. F. a specific gravity of 0.940 and at 68 deg. a viscosity of 25.8 determined by the Engler method.

The Fiat concern is now building two-stroke-cycle engines of both low-speed and high-speed types. The low-speed engines weigh from 110 to 88 lb. per hp., and the high-speed type from 44 to 35 lb. per hp.

For the past two years the Fiat Co. has been working experimentally on large oil engines for driving warships, but no tangible results have yet been reached.

The Fiat motor is characterized by not having independent scavenging pumps. The pistons are stepped, and while the upper part, of smaller diameter, acts as a working piston, the lower part, of larger diameter, acts as an air pump. This arrangement has been chosen to reduce the length of the motor and to obtain a better balance.

The upper part of the bed serves as a scavenging-air reservoir and contains air at from 0.2 to 0.4 atmospheres, according to the speed. The scavenging air is led through passages cast integrally with the bed and cylinders to the air valves. In the top of each cylinder head are two air valves with an atomizer and with the admission valve to start the engine. The exhaust ports are uncovered by the piston just before the lower dead center. All exhaust passages are water cooled. The compressor which is of the two-stage type is placed at the front end of the motor and is driven by an extension of the crankshaft and produces the compressed air for spraying the fuel,

starting and controlling the engine. Besides the compressor there is a water pump for cooling the cylinder walls and exhaust passages and also the lubricating pump.

An eccentric on the camshaft drives the inlet valves for the scavenging air and the fuel ignition. To reverse, it suffices to turn the camshaft back through an angle twice that corresponding to the injection period. Fig. 5 shows the Fiat valve gear.

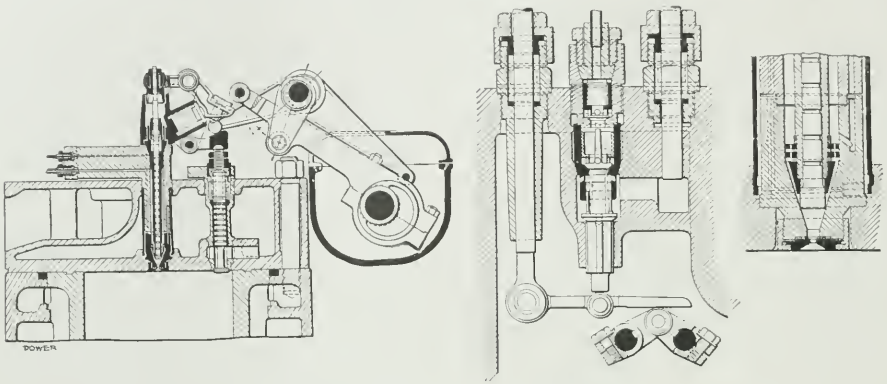


Fig. 5. Details of Fiat Valve Gear

Societa Italiana Langen & Wolf, Milan

The firm Langen & Wolf, of Milan, originally a branch establishment of the Deutz gas-engine factory, has lately developed, in addition to gas engines, one of the most important lines of Diesel engines for industrial purposes. Fig. 6 is a section through a four-cylinder, four-stroke-cycle engine of this make.

Körting Works, Sestrie Ponente
(Societa Italiana Körting)

The German firm Körting's branch establishment in Sestrie Ponente has built a four-stroke-cycle constant-pressure internal-combustion motor which soon found a great demand in Italy. It is made exclusively as a horizontal stationary engine and works on the Diesel principle. The firm also builds gas, petroleum and benzine motors for agricultural purposes, motors for airships and for small boats.

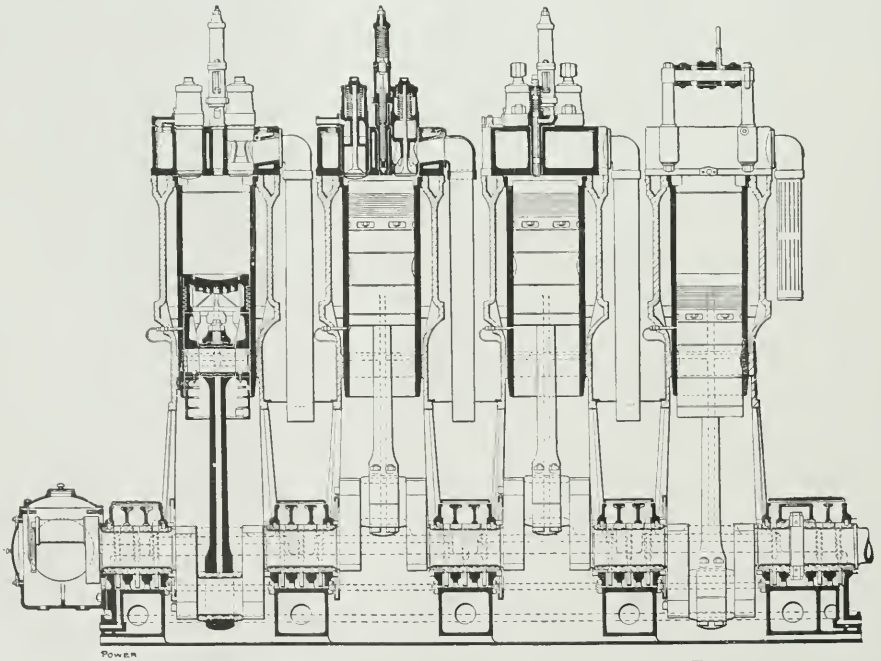


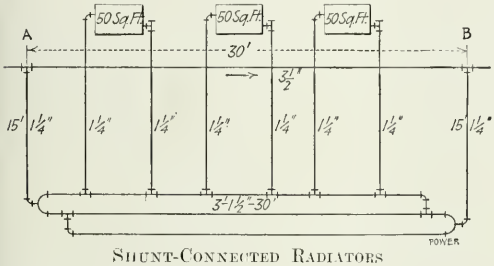
Fig. 6. Langen & Wolf Stationary Four-Stroke-Cycle Engine

HEATING AND VENTILATION

Shunt System of Connecting Radiators

By Ira N. Evans

Several articles have appeared explaining the action of the shunt system of connecting radiation on hot-water heating apparatus. The articles referred to are by L. L. Brewster, Feb. 4, 1913; W. L. Durand, Apr. 1, 1913, and H. A. Kieselbach, Aug. 12, 1913. The first article is erroneous in many respects and the last is by far the best explanation, but none give any concrete figures as to exactly what occurs in any given case. This is an excellent method of connecting risers and radiators in gravity house-heating work, as it gives a single main pipe, and the possibility of bypassing is avoided. It is, however, impossible to connect radiators situated below the level of the main in this manner unless forced circulation is used. A proper relation of the expected velocities should be known even then if the apparatus is to circulate properly at all times. If the pumpage is varied to regulate the temperatures it is apt to interfere with the circulation on connections of this character.



Shunt-Connected Radiators

In gravity work as long as the main is hot, the radiators will take care of themselves, and if radiator connections are made 1¼ in. for the first floor and possibly 1 in. for upper floors, they will be large enough. All that is necessary, for a proper size main, is not to give too great a drop for the total radiation. Mr. Brewster's thermo-siphon action is a new term for what happens on every hot-water job whether one or two risers are employed. As Mr. Durand states the action is caused in both cases by the difference in head between the two connections on the main. It is the purpose of this article to show how that difference in head may be calculated for any given case, as, for instance, the accompanying illustration, which shows radiator connections for an actual installation in a large institution in New York.

Mr. Brewster states, "It has been assumed and stated by some that the flow of water through the radiator is one of less resistance than that through the main but this is not the case." This statement is incorrect inasmuch as the resistance between A and B, Fig. 1, will be exactly the same for both main and shunt, the velocities changing to enforce the law, regardless of all other conditions.

Mr. Durand questions the practice of using 10 ft. per sec. in small mains. This may or may not be good practice as it is mainly a commercial question affecting the cost of installation. It is true that high velocities, where the head is great per unit of length, are not safe, due to possible inaccuracy of formulas at that point in the scale and that construction may not coincide with the plans.

Assuming a 4-in. main 1000 ft. long and a velocity of 8 ft. per sec., the head would be 69.1 ft. for the straight pipe. In another circuit on the same plant, 300 ft. long, the drop per 100 ft. would have to be 23 ft., and would mean a velocity of 10 ft. per sec. or over for all mains 2 in. and over with lengths 300 ft. or less.

If 4 ft. per sec. were the limit for small sizes, the long mains with large capacity would be unnecessarily expensive. This is almost wholly a matter of experience, judgment and initial cost. The drop in head should be known on all circuits and equal to the total head provided for circulation.

In the diagram, 6 ft. per sec. will be assumed for the 3½-in. pipe outside the shunt. Let

Q = Cubic feet of water flowing through 3½-in. pipe per sec.;
V' = Velocity in 3½-in. pipe within A and B;
V = Velocity in the shunt;
A' = Area of 3½-in. pipe;
A = Area of shunt.

Then

$$Q = A'V' + AV$$

The friction formula of Williams and Hazen developed in the July 9, 1912, issue of Power, reads as follows:

$$h = 0.00037 \times l \times \frac{V^{1.85}}{d^{1.166}}$$

The letters referring to the main will be designated by the prime mark and those referring to the shunt will be plain. Then

$$Head = l' \times \frac{V'^{1.85}}{d'^{1.166}} = l \times \frac{V^{1.85}}{d^{1.166}}$$

By solving the two expressions for the velocities it can be told whether the system will work or not. If the velocities are known and one diameter, the other diameter can be determined from the same equation.

The surface in the coil or radiator runouts, all of which are assumed to be 15 ft. long, will be for the 1¼-in. pipe

$$90 \times \frac{1}{2.3} = 39 \ sq.ft.$$

and for the 1½-in. pipe

$$30 \times 3 \times \tfrac{1}{2} = 45 \ sq.ft.$$

It requires 2.3 linear feet of 1¼-in. pipe and 3 ft. of 2-in. pipe to make 1 sq.ft. of surface. With radiators the total radiating surface will be 234 sq.ft. Assuming a maximum average water temperature of 200 deg., a room temperature of 65 deg., or 135 deg. difference, with 1.8 B.t.u. per hr. as the transmission factor, the total B.t.u. required per hour will be

$$234 \times 1.8 \times 135 = 56,862$$

The length of the three 1½-in. pipes in the coil in terms of 1¼-in. pipe is proportional to the areas, that is, the greater the area the shorter the length to be equivalent as far as friction is concerned.

Area 1¼-in. pipe = 1.5 sq.in. = 0.0104 sq.ft.; diameter = 0.115 ft.

Area 1½-in. pipe = 2.04 sq.in. = 0.0141 sq.ft.; diameter = 0.131 ft.

Area 3½-in. pipe = 9.9 sq.in. = 0.0687 sq.ft.; diameter = 0.297 ft.

The area of three 1½-in. pipes would then be

$$\frac{3 \times 2.04}{1.5} = 4.08$$

times the area of a 1¼-in. pipe. The equivalent length of coil in terms of 1¼-in. pipe, or the length of the shunt figured as 1¼-in. pipe will be

$$\left(\frac{1}{4.08} \times 30\right) + 30 = 37.353 \; ft.$$

$$h = \frac{37.353}{30} \times \frac{V^{1.85}}{d^{1.166}} = \frac{V'^{1.85}}{d'^{1.166}}$$

Substituting the numerical values for the diameters and solving for V in terms of V' by logarithms, gives

$$\frac{V}{V'} = \sqrt[1.85]{\frac{\left(\frac{0.115}{0.297}\right)^{1.166}}{1.2451}}$$

$$\frac{V}{V'} = \frac{((log\ 0.115 - log\ 0.297) \times 1.166) - log\ 1.2451}{1.85}$$

$$\frac{V}{V'} = \frac{(\bar{1}.0606978 - \bar{1}.4727564)\ 1.166 - 0.0952042}{1.85}$$

$$\frac{V}{V'} = \frac{-0.48091033 - 0.0952042}{1.85} = \bar{1}.688587 = log\ 0.4882$$

$$\frac{V'}{V} = \frac{1}{0.4882} = 2.0483 \text{ or } V' = 2.0483 \times V$$

Whatever the velocities outside the shunt, the relation of the velocities of shunt and main between A and B will be as above. This is based entirely upon the fact that the drop between A and B is the same for the main and the shunt and directly contradicts Mr. Brewster's assertion.

The drop in head between the points A and B will be less per unit of length than outside, due to the greater area. As the 3½-in. pipe has an area of 9.9 in. and the 1¼-in. pipe 1.5 sq.in., the velocity through the combined pipes would be

$$9.9 \div 11.4 = 87 \; per\ cent.$$

and the total friction between A and B would be $(0.87)^2$ or about 76 per cent. per unit of length of the friction outside the shunt. The total quantity of water flowing with a velocity of 6 ft. per sec. outside the shunt will be

$$6 \times 0.0687 = 0.4122 \; cu.ft.\ per\ sec.$$

for the 3½-in. pipe. The velocity in the 3½-in. pipe will be 2.048 times that in the shunt and the velocity in the shunt will be 0.488 times the velocity in the 3½-in. pipe between A and B. The velocity in the 1¼-in. pipe will be

$$0.4122 = 0.0687 \times 2.0483\ V + 0.0104\ V$$

$$V = 2.7277 \; ft.\ per\ sec.$$

Taking the weight of the water at the temperature as 60 lb. per cu.ft.

$$2.7277 \times 0.0104 \times 60\ lb. \times 60\ min. \times 60\ sec. = 6127.5\ lb.\ per\ hr.$$

If 56,862 B.t.u. per hr. are required, the maximum drop will be

$$\frac{56{,}862}{6127.5} = 9.28 \; deg.$$

The friction heads due to these velocities will now be worked out to see if they are equal as they should be. For the 1¼-in. shunt the friction head will be

$$h = 0.00037 \times 37.353 \frac{(2.7277)^{1.85}}{(0.115)^{1.166}}$$

$$h = \text{Log } 0.00037 + \text{log. } 37.353 + (\text{log } 2.7277)\ 1.85 - (\text{log } 0.115)\ 1.166;$$

$$h = \bar{4}.5682017 + 1.5723255 + (0.4357966)\ 1.85 - (\bar{1}.0606978 \times 1.166);$$

$$h = \bar{4}.5682017 + 1.5723255 + 0.9062237 + 1.0952264;$$

$$h = 0.0419773 = 1.1005 \; ft.\ head.$$

The friction head for the 3½-in. pipe will be

$$h = 0.00037 \times 30 \frac{(5.5872)^{1.85}}{(0.297)^{1.166}}$$

$$h = \text{Log } 0.0111 + (\text{log } 5.5872)\ 1.85 - (\text{log } 0.297)\ 1.166;$$

$$h = \bar{2}.0453230 + 1.3823026 + 0.6147660\bar{4};$$

$$h = 0.0423911 = 1.1025 \; ft.\ head.$$

The two heads prove up to the third figure, which is as close as the data in the problem.

If the Fanning formula were used and the velocity squared the friction factor, which changes for each velocity and size, would have to be obtained by trial and error. Using the friction factor for the velocity as heretofore determined, it would be 0.03 for the 1¼-in. pipe and 0.025 for the 3½-in. pipe. Fanning's formula is

$$h = f \frac{l}{d} \frac{V^2}{2g}$$

Substituting and placing the friction heads equal, with $l = 30$ ft. for 3½-in. pipe and 37.353 ft. for its equivalent in 1¼-in. pipe, gives

$$h = \frac{37.353 \times 0.03\ V^2}{0.115 \times 2g} = \frac{30 \times 0.025\ V'^2}{0.297 \times 2g}$$

Here $2g$ cancels and leaves

$$h = 9.7442 V^2 = 3.52525\ V'^2$$

$$\frac{V}{V'} = 0.509; \quad \frac{V'}{V} = \frac{1}{0.509} = 1.964$$

Substituting as before to get the true velocity

$$0.4122 = 0.0687\ V' + 0.0104 \times 0.509 V'$$

$$V' = 5.57 \; ft.\ per\ sec.$$

for the 3½-in. pipe as compared to 5.587 from the Hazen and Williams' formula.

$$0.4122 = 0.0687 \times 1.964 V + 0.0104\ V$$

$$V = 2.836 \; ft.\ per\ sec.$$

for the 1¼-in. pipe as against 2.7277 ft. per sec. from the first formula.

In the one case logarithms have to be used and in the other trial and error to get the friction factor. It is seen that the friction formulas agree fairly close, but the Hazen and Williams' formula would be safer as it gives a lower value for the velocity in the shunt.

When the radiator is first started up, if below the main, the cold water has to be raised to the main and the pressure due to the difference in weight of the cold and hot columns deducted. Assume that the temperature of the main is 200 deg. and that of the radiator 50 deg., as this

condition might occur in cold weather with the radiator shut off and it was desirous of turning it on. The actual cooling of the radiator has little or nothing to do with the circulation or the stopping of it.

Water at 50 deg. weighs	62.41 lb. per cu.ft.
Water at 200 deg. weighs	60.14 lb. per cu.ft.
Difference	2.27 lb. per cu.ft.

Dividing the 2.27 by 144 gives 0.0158 lb. per sq.in. pressure for each foot in height, and as the height is 15 ft., the following head will be obtained, remembering that head equals 2.33 times the pressure.

$$0.0158 \times 2.33 \times 15 = 0.55 \text{ ft. head}$$

As the friction head or power available is 1.10 ft. there will be sufficient head to produce circulation. As soon as the cold water is out of the radiator the velocity will be increased. The above assumptions presume a difference of 150 deg. If this were reduced to 10 deg. the normal drop in head due to gravity would be one-fifteenth, or

$$0.55 \div 15 = 0.036$$

It will be readily seen that in forced circulation with a drop of less than 10 deg. in the radiator gravity is practically eliminated.

Elements of Heating

By E. N. Irwin

Heat may be defined as a form of energy caused by the molecular motion of the particles of any substance. Its manifestations are contraction and expansion with changes in temperature measured by a thermometer. Electricity and light are analogous forms of energy, but the theory is of slight importance to the student of heating as compared with the manifestations which affect the physical action of the media used in heating. All heating quantities are based on the British thermal unit, which is the quantity of heat absorbed by one-pound weight of water when raised in temperature 1 deg. F. The mechanical equivalent of heat is 778 ft.-lb., to the B.t.u., a foot-pound being the energy or work required to raise a weight of one pound through a distance of one foot against the force of gravity. These quantities give a basis of measuring work for both heating and refrigeration, as in either system there is a transfer of heat from one point to another.

Water has the maximum absorbing power for heat, and is taken as the standard for measuring the capacity of other substances. This is expressed as a ratio which is called the specific heat of the substance. Water is taken as unity, so that the specific heat of any other substance will be the number of British thermal units required to raise a unit weight of it 1 deg. Conductivity is the number of British thermal units that will pass through a substance per degree difference either side in a unit of time. It is of importance in determining loss of heat in buildings and the transmission of heat through surfaces from one medium to another. The thickness is important as a greater weight will increase the absorbing power and delay the heat transmission.

Heat is transmitted by convection, radiation and conduction. Convection is the absorption of heat by the passage of a fluid over a heated surface, and the heat absorbed is a direct function of the velocity of passage. The transfer by radiation is the passage of heat from one object to another when not in contact. The sun transfers heat to the earth entirely by radiation. A stove in a room acts both by convection and radiation. The passage of the air of the room over the heated surface effects a transfer by convection; the fire transfers the heat to the sides of the stove mainly by radiation and the passage through the sides of the stove would be by conduction. Objects raised in temperature near the stove and exposed to the rays of heat would absorb heat mainly by radiation.

The condition or state of matter whether gaseous, liquid or solid is merely one of temperature. Thus water is solid below 32 deg., liquid from 32 to 212 deg. under atmospheric pressure and gaseous at any temperature above 212 deg. Pressures above or below atmospheric will change the above temperatures.

The three mediums used in heating are air, water and steam. A heating apparatus may be defined as a system of conduits or pipes arranged to convey a fluid from the source of heat to the space to be heated. The apparatus would include the absorber (heater, boiler, etc.), and the radiator on either end of the system of conduits. The apparatus may form a closed circuit returning the fluid to be reheated or it may be an open circuit wasting the conveying fluid after extracting as much of the heat as possible in the space to be heated. The fluid may be circulated, first, by an expansion from a higher to a lower pressure and temperature; second, by a difference in weight of the fluid as it is cooled or heated; third, by mechanical means such as the application of a pump or blower. Air and water may be mechanically circulated by independent power and the temperature of the medium will be independent of the power of circulation, that is, the circulation can be maximum without any transfer of heat. Steam is always circulated by expansion from a higher to a lower pressure, the latter being obtained by extracting the heat of the fluid in the space to be heated. Air and water may be circulated by gravity, due to a difference in temperature, and, therefore, weight, in different parts of the system. In all cases where the fluid is not mechanically circulated, the circulation is dependent on a temperature difference and, therefore, affects the average temperature of the heating medium. With a given initial temperature the more rapid the circulation the lower will be the average temperature of the heating medium, and the larger the surfaces required.

In studying the flow of steam as applied to heating, a knowledge of its physical properties is necessary, and as will be seen a knowledge of these properties will show that the rules governing steam heating are the same whether high or low pressures are used. Every temperature of steam in contact with the liquid in a boiler has a corresponding pressure which is fixed in all cases. In this state the steam is said to be saturated. When the steam is not in contact with the liquid and is raised above the temperature corresponding to the pressure, it is superheated, and the number of degrees above the temperature corresponding to the pressure is the degree of superheat.

With saturated steam the percentage of entrained water determines its quality. For example, with 2 per cent. moisture the quality of the steam would be 98. A reduction in pressure will tend to vaporize this water if the heat is maintained constant or heat is added. This is what happens when steam traps discharge to atmosphere under pressure above atmospheric.

Latent heat is the amount necessary to vaporize a

pound of water from liquid to vapor at the same pressure and temperature. It decreases with an increase in pressure and sensible temperature. The same amount of heat is released when the vapor changes back to water, as when steam is condensed in a radiator.

Sensible heat is the temperature recorded on a thermometer when immersed in the vapor, and in the case of saturated steam determines the pressure corresponding. When superheated steam comes in contact with the liquid a transfer occurs. Water is evaporated until the temperature of the liquid and vapor become the same, and when this occurs the steam will be saturated. The pressure will change at the same time to correspond to the final temperature of both vapor and liquid.

Total heat is the sensible heat plus the latent heat at the corresponding pressure plus the superheat if any. In heating work, only saturated steam is considered, although sometimes conditions of slight superheat occur in high-pressure steam lines.

Specific volume is the number of cubic feet of steam to the pound for any pressure and temperature and is an important factor in the design of conduits or mains. The sensible heat determines the temperature at which a heating system is operated and affects the heating surface in boilers and radiators. Attention is called to the fact that the total heat of steam only varies about 53 B.t.u. between atmospheric and 300 lb. absolute, the sensible temperature varies between 212 and 417 deg., or 205 deg., while the latent heat per pound varies from 970 to 811 B.t.u. In most steam tables the heat is measured from 32 deg., and the absolute pressure instead of atmospheric is used, the former being 14.7 lb. more than the former.

A universal question asked when heating apparatus are under consideration, is: "What is the best system or medium to use, air, steam or water?" At present it is possible to design apparatus so as to satisfactorily heat any building by any one of the three mediums, and any of the methods may be unsatisfactory if the system is designed, installed or operated improperly.

If air is circulated as a medium by difference in temperature and compared with water circulated by gravity the effect of specific heat and volume is given in the following: Where the specific volume of a medium is low, much higher velocities may be maintained with the same given expenditure of power or a greater difference in weight produced due to a given difference in temperature. The amount of heat transmitted is proportional to the density per cubic foot or the reciprocal of the specific volume. Assume velocities of 300 ft. per min. for the air and 30 lb. per min. for the water. For a given heat supply the relative cubic feet and size of conduits will be given. The size of conduits will be proportional to the cubic feet of the fluid required and inversely as the velocities. The velocities will vary inversely as the densities and specific heats.

Let Ha equal the volume in cubic feet of the hot-air system and Hw the volume of the gravity hot-water system. Then

$$Ha : Hw :: sp.ht.\ water : sp.ht.\ of\ air :: 1 : 0.24$$

$$Density\ water : density\ of\ air :: 62.5 : 0.075$$

$$Velocity\ water : velocity\ of\ air :: 30 : 300$$

$$\frac{Ha}{Hw} = \frac{30 \times 62.5 \times 1}{0.24 \times 0.075 \times 300} = 347$$

The hot-air conduits will be 347 times the size of the hot-water pipes. As the velocities are 10 to 1, there will be required 3470 cu.ft. of air to transmit the same heat as a cubic foot of water. Due to the greater areas of mains and corresponding outside surface the loss on the air system will be far greater for a given distance and the drop in temperature for the loss of 1 B.t.u. will be over four times that of the water. These are the real difficulties in handling air long distances as a medium for the transmission of heat. It is also true that the higher the temperature of the medium the greater the loss from radiation, and with air the greater the drop in temperature of the medium in transit.

Steam has low specific volume and high velocities, but the latent heat is an important factor which does not appear in a water system. The higher the average steam pressure the greater density and the smaller the pipe. The weight of steam at atmospheric pressure is 0.03732 lb. per cu.ft. and of water 62.5 lb. per cu.ft. The latent heat of the steam would be 970 B.t.u., while the drop on the water system would be only about 25 deg., or 25 B.t.u. per lb. The velocity of the steam would be about 3000 ft. per min. as against 30 ft. per min. for the water. The volume of steam over the water would be

$$\frac{62.5}{0.03732} = 1675\ times$$

Making a proportion in the same manner as before

$$Hs : Hw :: 62.5 : 0.03732$$
$$30 : 3000$$
$$25 : 970$$

$$\frac{Hs}{Hw} = \frac{62.5 \times 30 \times 25}{0.03732 \times 3000 \times 970} = 0.43$$

The water mains would thus be 2.3 times the size of the steam mains under the velocities and conditions named. Now, if the water was circulated 300 ft. per min., instead of 30, the water mains would be about one-fourth the size of the steam mains to do the same work. Of course, the water system requires the same size main for a return and the friction is greater than in the steam main. These figures are merely ratios giving an idea of how the physical properties of the different media affect the design of heating apparatus.

If the velocities are omitted, then the heat-carrying capacities per cubic foot will have the following relations:

$$\frac{Hw}{Hs} = \frac{62.5 \times 25}{0.03732 \times 970} = 43$$

or the water will have 43 times the capacity per cubic foot of the steam for delivering heat. The size of the mains reverses the ratio when the velocities are taken into account. The radiating surface is directly proportional to the difference in temperature and the coefficient of transmission, regardless of the medium. If the air, water and steam are at the same temperatures the same surface will be required, but a greater weight of air than of water will have to be passed over the surface, due to the low specific heat. In all cases this velocity is a function and from the above reasoning it will be seen that steam requires no more radiation than water if the temperatures of the steam and water are the same. The lower the temperature at which the heating system is operated, regardless of the medium, the greater the amount of surface and the higher the cost of installation.

EDITORIALS

Common-Sense Precautions

In a recent issue of POWER a contributor tells of an engineer who fell into a sump pit which was flooded with water. The place was inadequately lighted, and the pit was open and not even guarded by railing.

This accident is only one of a number of similar ones which occur altogether too frequently. There are innumerable plants where pit and pipe tunnels, shafts, raceways, etc., are in total darkness, and no attempt is made to prevent a person from falling into them. In some states it is made compulsory by law to safeguard employees in such places.

It reflects unfavorably upon the common sense of engineers not to take these precautions voluntarily. Much current is not required to properly light these places, and if they are not permanently lighted it should be insisted that the men use lanterns when going near or through them. Law suits for injuries received by employees and other disagreeable incidents can be thereby avoided.

The Third Congress of Refrigeration

The opportunity of a generation has just been afforded Americans interested in refrigeration, cold storage, ice making and the allied industries in having in this country the third international congress of refrigeration. The congress was a success, and the large attendance would indicate that it has been generally appreciated. Considerably over one hundred papers were delivered, and their publication in the proceedings which are to follow will make a valuable addition to the literature already in print.

The titles of the papers, which were almost equally divided between the sections, indicate in a general way the scope and character of the material presented. Quite a number of the papers were of foreign origin, and the exchange of ideas will, no doubt, be of equal advantage to all concerned, although a more extended discussion on the papers in the various sections would have greatly enhanced their value. Unfortunately, the contributed manuscripts arrived late, practically all of them at the last minute, and their publication was so delayed as to afford but little opportunity for a reading previous to their presentation. One man's ideas, particularly if he be an authority, are of value, but a discussion approaching any particular subject from many different angles adds to the general understanding and intrinsic value of a paper.

A number of resolutions were adopted by the various sections and referred to the general assembly of the congress or to the commission of the International Association of Refrigeration. The second section moved the general adoption of 143.5 B.t.u. as the latent heat of fusion of ice as explained in the report of the congress on other pages of this issue. The fifth section passed two resolutions referring to the transportation of refrigerated products by sea and rail, and the sixth section adopted resolutions referring to instruction and education in refrigeration, legislation and insurance against indirect damage. All of these resolutions were good and if followed out as intended should result in lasting benefit to the field as a whole.

Scientists and government officials of standing and some of the best engineers in this country attended the congress. According to the register there were thirty-five from France, twenty-five from Germany, eighteen from Russia, the same number from Austria, fifteen from Canada and lesser numbers from other countries in Europe, the British Empire, South America and even Asia. It is thus evident that the congress has a wide foothold in the various countries of the world and its influence will be felt in the 150 or more industries aided by artificial refrigeration.

A new era in refrigeration is just beginning and, as in the past few years, the development will be rapid. There will be plenty of work for the international association to do, and many questions for it to settle. Many of the best men in the field are included in its membership so that the ability is there to reflect credit on the organization. A continuation of the good work since its inception, five years ago, is to be looked for, and each succeeding congress should bear more fruit than the one preceding. So far this has been true and the gathering in Russia three years hence will, no doubt, live up to precedents.

Standardization of Boiler and Stoker Installations

The plea of Joseph Worker for real coöperation in standardizing boiler and stoker installations as told on page 500 of this issue, should be heeded.

While it is true that much has been done in this direction by the smoke-inspection departments of some cities, no movement of wide scope representing the concentrated efforts of boiler and stoker manufacturers and smoke inspectors has developed. It is hoped that the International Association for the Prevention of Smoke, before which Mr. Worker's paper was read, will be able to bring about such a movement. It is, perhaps, the organization best fitted for carrying on such work.

It is true that higher boiler settings, extended furnaces and stokers—in fact, all the requirements that make for commercially smokeless combustion of soft coal—cost more to install than equipments not specially designed for the fuel and load conditions, head room and floor space. The difference in price is the deterrent to their being more frequently adopted. Smoke-inspection departments might find it advantageous to circulate literature to the purchasers who are usually nontechnical men, showing that, although such installations are higher in first cost, they are far more economical than installations not so well adapted to the fuel and load conditions.

Previous to signing contracts, the purchaser should have his engineer call together the boiler and stoker manufacturers and smoke inspector for conference, so that such things as sizes of firebox, flues, chimneys, etc., may be agreed upon by each before the work commences. In this way, such unfortunate happenings as too little head room to allow of the proper distance between the grate and boiler, insufficient flue areas, due to structural features of the building, inadequate draft due to too small a stack; in fact, all these things which are discovered when it is too late to avoid great expense for remodeling, would then be avoided.

The Men You Keep

Occasionally men are found who have been employed by the same company fifteen, twenty, twenty-five years or more. This long service indicates a relation existing between the men and the company officials that promotes good will and a feeling of interest on the part of the men in the affairs of the company.

In a certain company one workman has been employed about forty years, and, although his efficiency is waning, he still receives full time for what service he renders. This company sells ice and coal to its workmen at cost; buries a man if he is killed, and takes care of the dependent ones until they can take care of themselves.

This company has never had any labor troubles, and when necessary the men willingly work overtime and all night for regular pay. Most men who leave the employ of the company return at the first opportunity. This company is known by the men it keeps.

As a contrast, take any company whose officials are not in close relation with the men, and where the one idea is to get as many dollars out of their efforts as possible. There can be but one result, discontent. The men feel the absence of personal interest in them and take the position that so long as the company is looking solely after its interests, it is up to them to get as much out of the company as they can. Hence, work is slighted—no one does more than he is obliged to do to hold his job. Periodically the discontent reaches the stage where a strike results. Such a company is known by the men it keeps.

When a man habitually makes changes, the fault is generally with himself. When a large part of the men employed by a company keep changing it looks as if the company were at fault. It does not take long for a company to get a favorable or discredited reputation from the men it keeps.

Very many boiler rooms are known as hard propositions. The firemen employed today are all gone next month, none staying longer than to find another position. A look into such a boiler room usually shows it to be dark and dirty, undermanned and indiscriminately operated. A good fireman will not work in such a place or for a company maintaining such a boiler room. Therefore, second-rate men are employed, efficiency is lacking and the plant gets a bad name among the craft. Another instance of being known by the men employed.

There is one kind of a plant which engineers avoid, if they are acquainted with the situation; that is, where the president, superintendent or general manager assumes the office of chief engineer. No engine room is large enough for two individuals to assume charge without friction, and if the management of the steam plant is divided, no end of trouble will occur. Discipline is impossible; the men, not knowing from whom to take orders, naturally obey the man who is nearest the office. It is not uncommon where such conditions exist for the chief engineer to quit in a short time, unless he is content to "play second fiddle." The men in the boiler and engine rooms take matters into their own hands to a greater or less extent, and do pretty much as they please.

No real engineer, capable of running a good power plant, can accept such conditions and the plant soon becomes known by the men it keeps.

The *Bismarck* (N. D.) *Weekly Tribune* wonders thus: "Has North Dakota a man who has succeeded in doing the hitherto impossible? Has she a wizard who has been able to break the seal on the closed book of mystery, delve into the unfathomable depths of gravity, and reveal her secret which prohibits perpetual motion?"

No, our dear contemporary, she has not. You can bet your whole outfit on it, job press and all. And if the alleged inventor, whose portrait you publish, says that he has produced a machine which has run forty days without tapping some sort of energy, he is either a liar or has himself fooled to a frazzle.

And the next mail brings the *Los Angeles Times*, with a weird account of an engine which, its owners say, "generates its own power in violation of recognized rules of mechanics and accomplishes the alleged impossibility of producing more power than it generates (absorbs? The noval feature is that the engine uses only air for fuel, the expansion of the air through heat producing driving power, as well as power to produce more heat to expand more air."

The following lucid description of the invention is reminiscent of the ramblings of the lamented Keely: "Wires from the magneto keep the air at the proper temperature without loss of power or pressure. The vital principle which enables the engine to multiply its power sixteen times is explained as a piston device that turns a shaft which carries two heavy flywheels. On each end of the shaft is a toothed gear. A groove is formed in a mangled device in which the end of the shaft travels. The groove is elongated and so placed that as the gear turns the end of the shaft will hold the gear in contact with the toothed rack and this causes the connecting-rods to produce a reciprocative motion. The drive shaft makes two and a half revolutions during each compression stroke."

It will go into the long time of similar fizzles as the E. M. Barnes attempt.

The *Electrical Review* publishes the following frank avowal from the pen of Douglas S. Martin: "When they have to fight the isolated plant, central-station men fight it not through personal animus toward the leaders of the movement, but because they are acting according to their convictions, and their convictions tell them that the isolated plant means waste. Therefore, they must set their rates to kill the isolated plant—not because they delight in killing, but because their line of business can only be run efficiently by raking in all loads and every kind of load."

READERS WITH SOMETHING TO SAY

Required Vacuum

Referring to the inquiry of F. E. K., in the Sept. 2 issue, I offer the following additions:

Because of the limited range of expansion in a reciprocating engine, the economy is limited. Owing to their great size and hence cost, cylinders could not be profitably built to allow for the tremendous increase in volume of steam when it is expanded to very low exhaust pressures. Consider the use of steam at an initial pressure of 165 lb. absolute; its specific volume in cubic feet per pound is 2.753, while at 1 lb. absolute it is 333. Imagine the size and cost of a cylinder necessary to utilize steam at the latter pressure. It would be simply prohibitive. Engines usually exhaust at about 6 lb. absolute and consequently all the available energy is not expended. Lower exhaust pressure would simply aid in decreasing the back pressure without any appreciable effect on the completeness of expansion. Even if it were possible to expand to 1 lb. absolute, any gain procured in expansion would be greatly offset because of the increased amount of condensation in the engine, unless highly superheated steam were used, and then the cost of the superheater would enter, for the fixed and operating costs of superheating must be taken into consideration in determining net gain, since the decrease in steam consumption would not be the actual saving.

H. W. Wetjen.

Newburgh, N. Y.

Home-Made Emery Wheel for Grinding Valve

I have heard and read of many ways of grinding valve seats, but never heard of a method like my own: Remove the disk holder from the valve stem and cut out the composition disk and fill up with emery with just enough thin glue to make the emery damp. Smooth off the top while damp and set away for a few hours; when the mixture hardens it makes a good emery wheel of the proper size. Place it in the valve and turn with a brace. If it is desired to use the disk holder in the valve, submerge it in warm water for a few minutes and scrape out the softened emery with a jack knife.

E. E. Thompson.

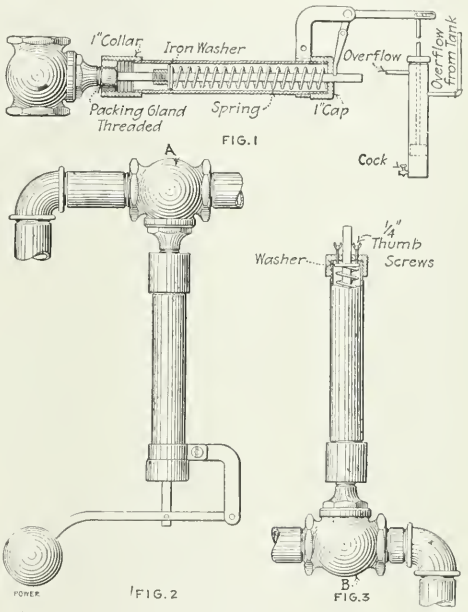
Thessalon, Ont., Canada.

Valve for Many Purposes

The illustrations show a valve that may be utilized for many purposes and made at little expense. Fig. 1 shows a valve I made several years ago to use as a safety stop on a pump used to fill a large tank with water.

This valve is made by threading the packing gland of a 1-in. globe valve after the threads have been filed off the stem and the stem extended as shown. A 1-in. collar and 1x8-in. nipple is screwed over the packing gland, first having placed a washer between the valve stem and the extension that will work free inside of the nipple. Over the stem place a spiral spring long enough so that when the cap is screwed on it will compress it slightly. Next pull out the stem as far as it will come, and cut a slot in it flush with the edge of the cap and arrange the trip as shown. The stop is then ready for service.

By removing the spring and attaching a float it makes a very good float valve, as shown in Fig. 2. By the addition of a washer as a compression plate and by tapping a ¼-in. hole on each side of the valve stem and inserting thumb screws (longer than illustrated), as shown in Fig. 3, a very good relief valve may be made, which may be regulated by compressing the spring. I have used this valve in many places and found it highly satisfactory.



Applications of Spring-Loaded Globe Valve

Claude R. Van Keuren.

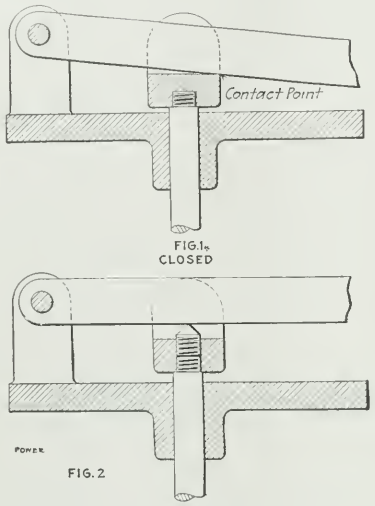
Famosa, Calif.

Leaky Safety Valve Repaired

I was called on to find what it was that caused a safety valve to operate in the following manner. The valve, when set to release at a certain pressure, would leak badly at a pressure far below the releasing pressure

and would not stop leaking until the pressure had fallen considerably.

On investigation I found that the trouble was due to the fact that the lever guide on the valve stem was flat. Fig. 1 shows the valve closed, the lever resting on the corner of the guide. The long fulcrum on guide



Defective and Correct Construction of Safety Valve Lever

allowed the lever to lift at a low pressure until it rested flat on top of the guide.

When the pressure had risen high enough the lever would be lifted by the other corner of the guide, which was a shorter fulcrum. To remedy this I drilled and tapped the top of the stem and inserted a plug having a point, as shown in Fig. 2.

Chas. G. Buder.

St. Louis, Mo.

Crescent Cooling Pond Defended

The letter signed by Charles W. Wilson, New Castle, Penn., on page 163 of the Feb. 4, 1913, issue, contains statements concerning our lake at Wampump, which are absolutely unwarranted by the facts. We beg to state positively that we have no knowledge of a Charles W. Wilson or anyone representing him calling on us for facts or having visited our plant.

Now to take up his statements in order:

His statement that there is no movement of the water is incorrect. He seems not to realize that water may flow without making the movement apparent on the surface.

His statement that the entire volume of the lake warms up and remains hot until cold weather comes on again is also incorrect, unless he refers to water on the surface only. The lake varies from a depth of from 6 to 12 in. at the upper end to 16 ft. in depth at the lower end next to the dam, and one can readily see the impossibility of it becoming equally warm all over when one considers there is a constant taking of cold water from the lower end of the lake at the bottom, where it is 16 ft. deep, and the consequent continuous flow of water from the upper end, where it is from 6 to 12 in. deep. By actual record, carefully made hourly and noted on our log sheet, we find even in hot weather there is a temperature difference of about 30 deg. F. between the intake water and the tail water.

His suggestion, "But with the addition of a properly designed cooling system it would be very successful in keeping the water cool during the summer season when the mill is running continuously night and day," is simply a statement wholly incorrect, so far as our conditions exist, and goes to show that he does not know anything about the operation of our mill, which has been running almost constantly for four years and for the last 12 months has been operating continuously night and day, with the exception of a shutdown of about ten days. During the hot months of this summer we ran continuously at full capacity under most economical conditions. We consider that we have the best, practical and economical system to fit our conditions.

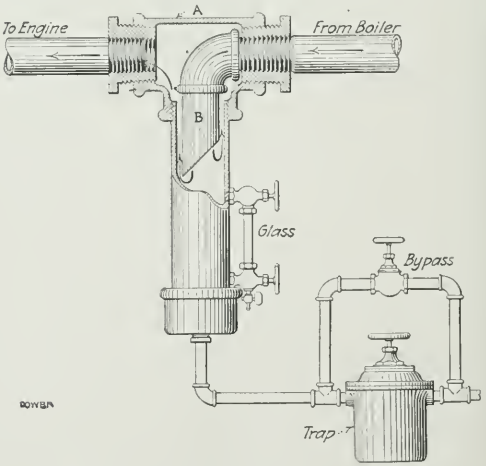
We do not have before us the article published in the Dec. 3, 1912, issue, but we have the original article from which it was abstracted. The original article appeared in the *Journal* of the American Society of Mechanical Engineers, being a paper read by our constructing engineer, W. B. Ruggles, of New York City, before the society. Mr. Ruggles is well known as an engineer of accuracy and truthfulness, and we write this letter principally to resent the careless, ignorant criticism of Charles W. Wilson. We invite any investigation that you or Mr. Wilson may see fit to make.

Crescent Portland Cement Co.,
David M. Kirk, President.

Wampump, Penn.

Home-Made Steam Separator

The illustration clearly shows the construction of a steam separator made of pipe fittings. The size of the fittings used will, of course, vary with the size of line on which the separator is to be placed.



Construction of Simple Steam Separator

The tee A should be much larger than the steam line to allow sufficient steam to get through the separator. By cutting the nipple or short length of pipe B on an angle, as shown, turning the long side toward the direction of flow, I believe more water can be taken from the steam than if the nipple is cut straight across.

A gage-glass is fitted to the drop leg and a steam trap is placed in the line draining this leg.

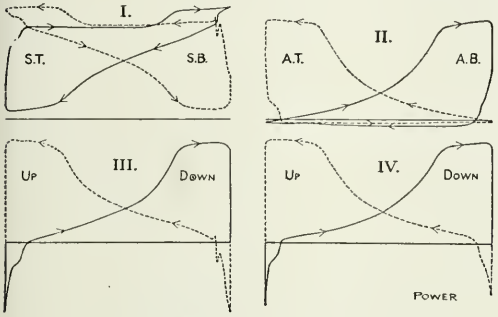
MARTIN MCGERRY.

Holley, N. Y.

Diagrams from Air Pump

In the issue of Aug. 15, Lester A. Fitts has given indicator diagrams from the steam end of a jet-condenser pump. The action of this type of machine is even more clearly shown by the diagrams herewith submitted, from both cylinders of an air-brake pump such as is found on every steam locomotive and is occasionally used as a small independent compressor.

The diagrams I and II are marked S and A for steam or air and T and B for top or bottom. Arrow-heads show



DIAGRAMS FROM AIR PUMP

the direction of tracing by the pencil, and two kinds of lines are used, to separate the two-cylinder ends distinctly and to show which diagrams go together: thus steam-top and air-bottom have their high-pressure stroke (steam admission and air compression) downward and their low-pressure stroke (exhaust and suction) upward.

The effect of and need for the peculiar form of the steam diagrams are made clear by the effective pressure curves at III and IV, from steam cylinder and air cylinder, respectively. These are derived by the usual method of combining pressures on the two sides of the piston. Effective steam pressure (III) is a driving force, in the direction of piston motion, when measured upward from the base line; effective air pressure, when similarly measured upward at IV, is a resisting force opposing the movement. The manner of variation of air pressure is, of course, the independent and determining action, to which the steam pressure must accommodate itself. A very close comparison of curves III and IV will bring out some discrepancies, apparently due to inaccuracies of indicator movement, but on the whole the agreement is very good, as it should be. The two pictures are of the same size, so that the steam and air curves are directly comparable.

A feature of construction which has a strong influence upon steam action, especially in causing throttling of exhaust and high-back pressure during the first, high-speed part of each stroke, is the use of very small steam ports. In this particular machine the port area is only about $\frac{1}{130}$ of the piston area, as against a ratio of about 1 to 10 in ordinary engines.

The machine is rigged for indicating by putting on a light extended piston rod, tapped into the lower end of the main rod. This passes through a special stuffing-box, which replaces the plug in the bottom cylinder head. The rod drives a suitable reducing motion, and the cylinders must be drilled and tapped for the indicators. This little compressor makes a very effective laboratory unit.

ROBERT C. H. HECK.

New Brunswick, N. J.

Jam Nuts

Your note at the foot of Charles Jablow's letter on "Jam Nuts" in issue of Sept. 9, will not hold water. You say, "it is both necessary to obtain the maximum draft before setting the jam nut and to obtain the position of the inside nut without backing it against the outside nut," etc.

With your method, when you set up the outside nut you displace the inside nut by the amount of lost motion (and all nuts have some) and derange your bearing adjustment by just so much and take all the strain on the thin nut. I believe the cut is correct and the note is wrong.

C. H. MANNING.

Manchester, N. H.

Why Did Hot-Water Tank Fail?

The failure of a hot-water tank, described by Mr. Cederblom in the July 22 issue, was undoubtedly due to the breathing action of the tank ends. The breathing would be accentuated by the high pressure, the absence of air cushioning, and the neglect of the designer to adequately brace the ends with gusset plates or by other means. The pitting may have been assisted also by some deleterious ingredient in the water. Even with properly braced Lancashire and Cornish boilers the writer has frequently noticed a decided tendency to "groove" around the turned-over flange of the end plates (although such action does not usually become serious until the boiler has been in service for 10 to 20 years) and in practically every case the only reasonable cause to which the grooving could be assigned was the breathing action which undoubtedly takes place to some extent in all boilers, no matter how well they are stayed.

JOHN S. LEESE.

Manchester, Eng.

The greatest long-distance power transmission in southern Asia is in the native state of Mysore, power being transmitted from the Cauvery falls to the Kolar goldfields, 92 miles away, and to the cities of Mysore and Bangalore, about 40 and 86 miles away, respectively, for electric lighting and power purposes. Nearly all of the hydro-electric installation for this great enterprise was made in Schenectady, N. Y., and the only imports connected with this work not from the United States were waterwheels imported from Switzerland. An important extension for this great enterprise has recently been started, and the contract for all machinery except waterwheels has gone to the United States. Power is sold to the mining companies at $48 per horsepower-year.

ENGINEERS' STUDY COURSE

Boiler Efficiency—III

After a test has been conducted considerable work remains to be done in figuring out the results so as to make the report complete. Last week we gave an extensively used form of test report, partly filled in with the data of an imaginary test. While it should be possible for every reader who has followed this series with reasonable application, to fill in the balance of the report without further illustration, it seems desirable to present the calculations in full here to serve as a sort of review.

Fuel

The first item to be calculated is the total weight of dry coal supplied to the furnace, which is found by simply multiplying the total weight of coal as fired by 100 minus the percentage of moisture and dividing by 100 thus:

$$\frac{10,372 \times (100 - 7)}{100} = 9646 \text{ lb.}$$

The percentage of ash and refuse in the dry coal equals the total weight of ash and refuse taken out divided by the total weight of dry coal supplied and multiplied by 100, as follows:

$$\frac{1897}{9646} \times 100 = 19.67 \text{ per cent.}$$

To calculate the proximate analysis of the dry coal from the analysis of the coal as fired, add together the percentage of volatile matter, fixed carbon and ash, divide each in turn by their sum and multiply by 100, thus:

$$3.49 + 76.35 + 13.16 = 93$$

then, the percentage of volatile matter in the dry coal is

$$\frac{3.49}{93} \times 100 = 3.75 \text{ per cent.}$$

the percentage of fixed carbon is

$$\frac{76.35}{93} \times 100 = 82.1 \text{ per cent.}$$

and the percentage of ash is

$$\frac{13.16}{93} \times 100 = 14.15 \text{ per cent.}$$

The same proceedure is employed in calculating the analysis of the combustible matter, except in this case the percentage of ash is also left out. This analysis is: volatile, 4.37, and fixed carbon, 95.63 per cent.

Analysis of Ash and Refuse

An actual analysis of the ash and refuse may be made in the same way and with the same apparatus employed in making the proximate coal analysis or the analysis may be estimated. This is done by subtracting the estimated total weight of real ash from the actual total weight of ash and refuse, dividing the difference by the latter and multiplying by 100. This gives the percentage of combustible matter in the ash and refuse and the difference between this figure and 100 gives the percentage of incombustible matter. The figures in the present case are

$$\frac{10,372 \times 13.16}{100} = 1365 \text{ lb.}$$

estimated total ash and, hence,

$$1897 - 1365 = 532 \text{ lb.}$$

combustible matter in the ash and refuse, making,

$$\frac{532}{1897} \times 100 = 28 \text{ per cent.}$$

combustible matter in the ash and refuse and, hence,

$$100 - 28 = 72 \text{ per cent.}$$

incombustible matter.

The average weight of dry coal consumed per hour is the total weight consumed divided by the number of hours, or,

$$9646 \div 10 = 964.6 \text{ lb.}$$

and the pounds consumed per square foot of grate per hour is the total weight consumed per hour divided by the area of the grate in square feet, thus:

$$964.6 \div 62 = 15.55 \text{ lb.}$$

Heat Value of Coal

To estimate the heat value of the dry coal the chart given in the June 10 lesson will be required. The percentage of fixed carbon in the combustible matter has just been found to be 95.63. Locating this point on the bottom of the chart printed in the June 10 issue and tracing a vertical line up to the curve, then across to the left margin shows that the heat value of the combustible should be about 14,900 B.t.u. per lb. As the combustible matter composes but 85.85 per cent. of the dry coal, the heat value of 1 lb. of dry coal will be but 85.85 per cent. of that of 1 lb. of combustible, or,

$$\frac{14,900 \times 85.85}{100} = 12,792 \text{ B.t.u.}$$

and, as the combustible matter in 1 lb. of coal as fired equals only 79.84 per cent., the heat value of 1 lb. of coal as fired is only

$$\frac{14,900 \times 79.84}{100} = 11,896 \text{ B.t.u.}$$

To estimate the heat value of the combustible from the heat value of the dry coal as shown by the calorimeter test it is simply necessary to invert the latter part of the above process. The 12,600 B.t.u. shown by the calorimeter to be the heat value of 1 lb. of dry coal is really the heat value of the 0.8585 lb. of combustible contained in a pound of coal. Hence, the heat value of one whole pound of combustible must be

$$12,600 \div 0.8585 = 14,677 \text{ B.t.u.}$$

The heat value of the coal as fired is figured from the heat value of the dry coal, as shown by the calorimeter in exactly the same manner as in the case of the estimated values just illustrated. Thus, the heat value of the coal as fired is

$$\frac{12,600 \times 93}{100} = 11,718 \text{ B.t.u. per lb.}$$

Moisture in Steam

The quality of the steam may be estimated by the formula given in the Sept. 16 issue as follows:

$$Q = \frac{(H - h) + 0.46\,(T - T_1)}{L}$$

For the conditions of the test H, the total heat of dry-saturated steam at atmospheric pressure, equals 1150.4 B.t.u. per lb.; h, the heat of the liquid corresponding with the pressure carried in the boiler, equals 300.6 B.t.u. per lb.; T, the temperature on the discharge side of the steam calorimeter, equals (see last week's lesson) 272 deg. F.; T_1, temperature of saturated steam at atmospheric pressure, equals 212 deg., and L, the latent heat of steam at the boiler pressure, equals 886.3 B.t.u. per lb. Substituting these values in the formula we have

$$Q = \frac{(1150.4 - 300.6) + 0.46\,(272 - 212)}{886.3}$$

$$= \frac{849.8 + 27.6}{886.3} = 0.99$$

or 99 per cent., which means that there was

$$100 - 99 = 1 \text{ per cent.}$$

of moisture in the steam.

The water fed to the boiler per hour is the total water fed divided by the number of hours, thus:

$$83{,}125 \div 10 = 8312.5 \text{ lb.}$$

The water actually evaporated per hour is the water fed per hour multiplied by the quality of the steam expressed as a decimal fraction, or,

$$8312.5 \times 0.99 = 8229.4 \text{ lb.}$$

The formula of calculating the factor of evaporation, as given in the Sept. 9 issue, is

$$F = \frac{(H - t) + 32}{970.4}$$

For the conditions of the test H, the total heat above 32 deg. in the steam at boiler pressure, equals 1186.9 B.t.u. per lb., and t, the temperature of the feed water, is 199 deg. Substituting in the formula, we have

$$F = \frac{(1186.9 - 199) + 32}{970.4} = 1.051$$

The actual equivalent evaporation per hour is the actual evaporation per hour multiplied by the factor of evaporation, thus:

$$8229.4 \times 1.051 = 8649 \text{ lb.}$$

The horsepower developed is the average actual equivalent evaporation per hour divided by 34.5; hence, the horsepower developed in the present test was

$$8649 \div 34.5 = 250.7$$

The percentage of builders' rating developed is found by dividing the horsepower actually developed by the builders' rating and multiplying by 100, thus:

$$\frac{250.7}{220} \times 100 = 114 \text{ per cent.}$$

The water apparently evaporated per pound of coal as fired under actual conditions equals the water actually fed per hour divided by the weight of coal per hour as fired, or,

$$8312.5 \div 1037.2 = 8.01 \text{ lb.}$$

The actual equivalent evaporation per pound of coal as fired equals the above figure multiplied by the quality of the steam (expressed as a fraction) and the factor of evaporation, thus:

$$8.01 \times 0.99 \times 1.051 = 8.33 \text{ lb.}$$

The actual equivalent evaporation per pound of dry coal fired equals the actual equivalent evaporation per hour divided by the number of pounds of dry coal supplied per hour, or,

$$8649 \div 964.6 = 8.97 \text{ lb.}$$

In estimating the analysis of the ash and refuse we found that a total of 532 lb. or 53.2 lb. of combustible matter fell through the grate to the ashpit.

The dry coal fired per hour weighed 964.6 lb. and of this 85.85 per cent., or 828.1 lb., was combustible matter. Hence, the percentage of combustible matter falling to the ashpit was

$$\frac{53.2}{828.1} \times 100 = 6.42 \text{ per cent.}$$

As the combustible matter comprised 85.85 per cent. of the dry coal and as all the heat was furnished by the combustible matter, it is evident that the 8.97 lb. actual equivalent evaporation per pound of dry coal fired was really 8.97 lb. actual equivalent evaporation per 0.8585 lb. combustible matter fired. Hence, the actual equivalent evaporation per pound of combustible fired must be

$$\frac{8.97}{0.8585} = 10.45 \text{ lb.}$$

But, 6.42 per cent. of the combustible fired fell into the ashpit, was unburned and, hence, supplied no heat. Therefore, the 10.45 lb. actual equivalent evaporation per pound of combustible fired is 10.45 lb. per

$$\frac{100 - 6.45}{100} = 0.9355 \text{ lb.}$$

of combustible burned, or,

$$10.45 \div 0.9355 = 11.17 \text{ lb.}$$

per pound of combustible burned.

The heat absorbed per pound of combustible burned equals the number of pounds of actual equivalent evaporation per pound of combustible burned multiplied by the latent heat of steam at atmospheric pressure, or 970.4. Then, in the present case the heat absorbed equals

$$11.17 \times 970.4 = 10{,}839 \text{ B.t.u.}$$

and, as the heat value of a pound of combustible was found to be 14,677 B.t.u., the efficiency of the boiler is

$$\frac{10{,}839}{14{,}677} \times 100 = 73.58 \text{ per cent.}$$

In a similar way the efficiency of the boiler and grate equals the actual equivalent evaporation per pound of coal fired, multiplied by 970.4 and divided by the heat value of 1 lb. of coal and all multiplied by 100, thus:

$$\frac{8.97 \times 970.4}{12{,}600} \times 100 = 69 \text{ per cent.}$$

If the actual equivalent evaporation per pound of coal as fired was 8.33 lb., the number of pounds of coal as fired required to evaporate 1000 lb. of water from and at 212 deg. was

$$1000 \div 8.33 = 120$$

and as this quantity is

$$\frac{120}{2000} \times 100 = 6 \text{ per cent.}$$

of one ton, the cost of evaporating 1000 lb. of water was

$$\frac{2.90 \times 6}{100} = \$0.174$$

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Several German students refused to toast their emperor in beer on his recent jubilee. One was expelled, one sentenced to confinement in the university dungeon. Rather than occupy a dungeon cell, we'd toast Anthony Comstock in hunyadi water.

⁂

Prof. Munier has forsaken his pedagogical career to go into business for himself. He's selling peanuts, popcorn, hot dogs and ice-cream cones. Here's a tip to our professorial friends now teaching the young idea how to shoot, and whose emoluments are too little. This is a business age, and we need the dough. Selling peanuts is the only shell game where you find the little pea under the shell you bet on.

⁂

Oil has seeped into the crematory business. One of its advantages is that complete incineration takes place in two hours—you're just ruined if they get you! While cremation may never become so popular as the seventy-two-dollar funeral, if you have a hunch that you'd like this type of ash-handling machine in yours, the oil-burner may appeal to you.

⁂

"The Boston Elevated does not pay its president $36,000 and other officials from $4000 to $15,000 a year because it wants to, but because it has to. Ability comes high!" Try this argument on the boss if you think you can get away with it.

⁂

It's marvelous, the growth of the refrigerating industry in these United States. Its machinery is capable of turning out nearly 20,000,000 tons of ice yearly and it has an invested capital of $150,000,000. What, no ice? Geddap!

⁂

Multimillionaires' incomes are largely imaginary and trifling, says a contemporary, when compared with the savings of us small fry. We don't speak to over a dozen of these "multi" chaps, but we're sympathetic, all right. Who's suffering now?

⁂

Prof. Wirth of Germany has invented a method of controlling fast-moving trains by electric waves. We have a new haven over here for a few bunches of any old kind of waves which will stop trains before they stop themselves by running into something.

⁂

Our human nature is sure funny. When Mayor Gaynor was alive the great majority of the press and the people seldom missed a chance to ridicule or sneer at him. The other day the editorial and news columns lauded him to the skies and hundreds of thousands of that dear public lined the sidewalks as the funeral procession passed, baring their heads to do him reverence. Say, we are funny!

⁂

There's more than seven hundred billion tons of coal in the world's reserves. Coal is about the only thing that isn't almost ruined by the early frost every spring, thereby sending the price up into the heavens. Let's be thankful for that.

⁂

Nobody knows! After forty years' service as an engineer, unmarred by a single accident, Irwin De Raney was killed in the yard five minutes after affectionately patting his old locomotive and bidding his friends goodby. De Raney had just retired and the next day was to be put on the pension list.

⁂

There's a movement on foot to have an electrical-resuscitation hero medal for men who save the lives of victims of electric shock. It's a good stunt if for no other reason than the examination before the award compels the hero to give some valuable information as to how he did it.

⁂

Electricity has taken to the woods and has driven the picturesque lumber-jack, some of him at least, from his old-time trade. A motor-driven timber-hauling and loading apparatus now clears a radius of 4000 ft. without having to move the outfit. Next they will be cutting and driving by electricity—perhaps.

Getting to Work under the New Indiana Inspection Law

Thirty boiler insurance company officials, attaches of the state boiler-inspection department, and John Gallavin, boiler inspector, under the state bureau of inspection, held a meeting in the house of representatives at the state house recently, to discuss the Indiana boiler inspection law, passed by the 1913 legislature. The meeting was called by Mr. Gallavin to study the question of the application of the new law throughout the state. A desire to avoid confusion in the interpretation of the statute was responsible for the meeting, Mr. Gallavin said. Supervisors of boiler insurance companies from several states appeared at the meeting.—"Indianapolis News."

⁂

National Tube Co. Awards Prize

At the Springfield Convention of the N. A. S. E. the National Tube Co. exhibited an N. T. C. regrinding valve which had been used for several years on a machine testing Kewanee unions. Engineers were given an opportunity to guess how many times it had been opened and closed, the number of times corresponding, under the conditions of its use, to the number of unions tested.

An affidavit was on file signed by Mr. Marshall, of the National Tube Co., Kewanee Works, to the effect that it had been opened 2,650,000 times, and the nearest estimate was that submitted by William H. White, 61 Fulton Ave., Rochester, N. Y., superintendent of the Rochester Railway & Light Co., his estimate being 2,648,500 times. Mr. White received the walrus-skin bag which was offered to the person making the nearest estimate.

⁂

W. A. Blonck Lectures on Boiler Practice

On Monday evening, Sept. 29, W. A. Blonck, of Chicago, inventor of the Blonck boiler efficiency meter, gave a very interesting talk before Newark, N. J., No. 3 Association of the N. A. S. E. About 120 engineers heard Mr. Blonck. The lecture was by direction of the State Educational Committee.

Mr. Blonck deplored the lack of thorough standardization in boiler furnace, stoker and chimney construction and design, stating that he did not expect one standard to answer for the East and West, with their varying fuel conditions, but there was no reason why these things should be installed on the hit-or-miss plan now so common. The speaker claimed that investigations in numerous plants led him to believe that where stokers were installed, the engineers did not give the stokers the attention required for best results, and hence these boiler plants were not operating as efficiently as ordinary hand-fired plants.

Charts showing curves of CO_2 percentages and steam in pounds as shown by steam flow meters in the Fisk St. station of the Chicago Commonwealth Edison Co., where 120 boilers are installed and where 4000 tons of coal is burned per day, were shown. The steam quantity line as plotted from records made by a steam-flow meter showed very great fluctuations which did not check with the lines plotted to show the indications of the Blonck boiler efficiency meter attached to the boiler being tested. Investigation showed that these fluctuations were not due to any changes in the furnace or in the intensity of the fire, but to the water tender opening the feed valve admitting much feed water (at 212 deg. F.), thus momentarily reducing the steam production. The increase lines of the peaks, indicating a sudden increase in production, were caused by sudden demands for steam which reduced the pressure enough to cause much water to flash into steam.

The speaker stated that investigations by himself revealed that drops as great as from 140 to 60 per cent. boiler rating occurs, due to the causes mentioned above and not to any changes in furnace temperature or volume of gases passed. For this reason one should be careful not to blame furnace conditions for all steam quantity fluctuations indicated by a steam flow meter.

A practice condemned by the speaker and one which he said was unbelievably common was that of running boilers underloaded. Mr. Blonck mentioned numerous plants recently visited by him, where there were three or more boilers to a plant and each boiler was operating at half load and sometimes less. When a boiler cannot be run steadily at about 125 per cent. rating without burning the arches and setting, the speaker said, there was something wrong with the settings, yet this condition is by no means uncommon. He pointed out that there was a too credulous acceptance of the apparent fact that maximum draft meant maximum steam production.

Third International Congress of Refrigeration

The Third International Congress of Refrigeration is now a matter of history. Delegates to the number of 147 from 20 foreign countries were present and 600 from our own country were registered. A large number of papers were presented, some of exceptional interest, and an excellent exposition of refrigerating machines, materials and processes added greatly to the interest of the meeting, as America's latest and best achievements in the refrigerating line were there and thus showed in the best possible way the present state of the art. Other associations and societies related to the refrigerating field held their conventions at Chicago during the Congress, so that upward of 2500 men interested in refrigeration or cold storage were present to take some part in America's first Congress.

During the week of Sept. 7 to 13, many of the foreign delegation arrived in New York and spent the time sight seeing in and about the city until Sunday, Sept. 14, when the entire party left for Washington. On Monday, Sept. 15, the formal organization of the Third International Congress of Refrigeration was effected at the auditorium of the National Museum in Washington. Dr. F. W. Gunsaulus, of Chicago, president of the Congress, presided. In the absence of the President of the United States, William Jennings Bryan extended a semi-official welcome. Doctor Gunsaulus in the opening address pointed out that "waste of food is a crime against civilization," and that the remedy was to be found in refrigeration. A few remarks on the organization of the Congress were made by W. J. Rushton, of Birmingham, Ala., president of the American Association of Refrigeration. Andre Lebon, president of the International Association of Refrigeration, ex-Minister of the Colonies and ex-Minister of Commerce, Paris, France, was then presented and thanked the American Government for the hearty welcome extended. Short addresses by representatives of various countries followed and the rest of the day was spent in seeing some of the attractions of Washington. In the evening an official reception was given at the Pan-American Union Building. On Tuesday morning, President Wilson returned in time to greet the delegates, who immediately left for Chicago, the center of the cold-storage industry in this country.

Hotel La Salle was headquarters for the Congress. Wednesday morning, Sept. 17, was given over to registration and an official welcome to Chicago by Corporation Counsel Sexton, acting in behalf of Mayor Harrison who was absent from the city. In the afternoon the six sections of the Congress held their opening organization sessions, which were short and consisted of presidential addresses, announcement of honorary presidents, reading of rules and regulations and the reports of commissions. Thereafter with the exception of Friday, when everybody went to Milwaukee, one session was held daily, the balance of the time being devoted to entertainment, sight-seeing and social functions.

Many of the papers presented before the six sections are not of special interest to "Power" readers, but the following complete program of the papers will give some idea of the scope and nature of the subjects treated.

SECTION I. LIQUIFIED GASES AND UNITS

President, William Kent; vice-president, D. S. Jacobus; secretary, Calvin W. Rice.

Papers: "Lecture on Liquid Air and Its Uses," by Georges Claude; "Notes on the Work of the Section for Physics, Chemistry and Thermometry of the First International Commission of the International Association of Refrigeration," by Prof. H. Kamerlingh Onnes; "Critical Point of CO_2—a Possible New State of Matter," by Gardner T. Voorhees; "Report on the Unification of the Values, Units, Terms and Symbols Used in the Refrigerating Industry," by P. Juppont; "Essay on the Equations of Dimensions," by P. Juppont; "Observations and Propositions Relative to the Nomenclature and the Formation of Symbols for Refrigeration Values," by P. Juppont; "The Latent Heat of Fusion of Ice," by H. C. Dickinson, D. R. Harper and N. S. Osborne; "Heat from the Fusion of Ice," by A. Leduc; "Discussion of Earlier Measurements of the Thermodynamical Properties of Ammonia and Methylchloride," by G. Holst; "Some Physical Properties of the Liquid and Gaseous Phases of Ammonia," by Robert E. Brownlee, Henry A. Babcock and Frederic C. Keyes; "Optical Magnetic Phenomena at Very Low Temperatures, Divers Phenomena of Phosphorescence at Very Low Temperatures, Hall's Phenomena at Low Temperatures," by Jean Becquerel; "Production of Hydrogen," by Dr. F. Linde.

SECTION II. REFRIGERATING MACHINERY AND INSULATING MATERIALS

President, Dr. Alexander C. Humphreys; vice-president, N. H. Hiller; secretary, Van Rensselaer H. Green.

Papers: "What Thickness of Insulation Should Be Used in Refrigerating Plants," by Ernst Rossner; "Insulation," by R. L. Shipman; "Compressed Exhaust Steam for Ice Making and Refrigeration—New Method and Apparatus," by Gardner T. Voorhees; "Some Suggestions as to Speed Rating for Ammonia Compressors," by Horace C. Gardner; "Multiple Effect Absorption Machines and Their Employment for Heating," by Edmund Altenkirch; "The Refrigerating Machine as a Heating Means—Reversible Heating," by Bernard Tenchkof; "Preliminary Report from the Thermal Testing Plant of the Pennsylvania State College," by J. A. Moyer; "Comparative Installation and Operating Cost of a Combined Ice Manufacturing and Cold Storage Plant," by R. H. Tait and L. C. Nordmeyer; "On a Method of Calculating the Thickness of the Insulating Walls of Cold Storage Rooms," by M. L. Marchis; "Concrete in Cold-Storage Warehouse Construction," by J. H. Libberton; "Telethermometers and Telehygrometers for Cold Stores," by F. W. Robinson; "Multiple Effect Compressors and Multiple Effect Receivers," by Gardner T. Voorhees; "A New Air Refrigerating Machine Eliminating the Use of Water," by C. Monteil.

SECTION III. APPLICATION OF REFRIGERATION TO FOOD

President, Dr. Harvey W. Wiley; vice-president, C. H. Parsons; secretary, Dr. M. E. Pennington.

Papers: "Australia and New Zealand as Sources of Meat Supply," by A. W. Pearse; "Factors Influencing Changes in Storage Butter," by L. A. Rogers; "The Different Methods of Refrigeration Compared from the Standpoint of the Hygrometric Conditions of the Air in the Cold Rooms," by A. Blanchet; "Source and Distribution of Fruits and Vegetables Handled in the Minnesota Primary Markets," by C. W. Thompson; "Local Cold Storage in Canada," by J. A. Ruddick; "Wisconsin as a Factor in the Nation's Supply of Butter," by Prof. C. E. Lee; "Bacterial and Enzymic Changes in Milk and Cream Kept at 0 deg. C.," by Pennington, Hepburn and St. John; "Preservation of Eggs by Refrigeration in Sterile Air," by M. F. Lescarde; "Application of Refrigeration to Fruit Juices," by H. C. Gore; "Notes on Investigation of Better Methods for Preserving Fish by Artificial Cold," by S. M. Bottemanne; "The Use of Refrigeration in the Preparation of Dried Cultures of Bacteria," by L. A. Rogers; "Rural Cold-Storage Plants—A Scientific and Economic Necessity," by P. H. Bryce; "Vital Statistics of Refrigeration—Its Present Status in Different Countries of the World," by A. W. Pearse; "Speculation as an Element in the Cold Storage of Food," by Herbert H. Pease; "The Effect of Prolonged Cold Storage on the Chemical Composition of Fish," by W. G. Gies; "Report of Work Done by Scientific Members of the Commission for the Investigation of Better Methods of Preserving Fish by Artificial Cold," by A. B. Droogleever-Fortuyn; "The Fish Production of the Great Lakes of the United States and Canada and the Practical Application of Refrigeration on Freezer Storage," by C. C. Robbins; "The Fish Production of the Pacific Coast of the United States and Alaska and the Practical Application of Refrigeration on Freezer Storage," by J. J. Maddock; "Freezer Storage as Applied to the Fish Production of the New England Section and the Atlantic Coast of the United States," by M. J. Talson; "Observation on the Use of Refrigeration and Freezer Storage in the Fish Industry of the United States," by Kenneth Fowler.

SECTION IV. INDUSTRIAL REFRIGERATION

President, M. L. Holman; vice-president, R. H. Tait; secretary, Prof. E. H. Ohle.

Papers: "The Relation of Refrigeration to Biological Materia Medica," by A. W. Parker Hitchens, M. D.; "The Condensation and Conservation of Wine and New Wine by Means of Cold," by Dr. Johannes Caspar; "Progress Made in the Use of Low Temperatures in the Textile Industry," by Dr. F. Erban; "Pipeline Refrigeration," by G. F. Bein; "A New Method of Ventilation for Dry Air Cold Storage Plants Using Natural Ice," by Anton Genert; "Air Cooling and Dehumidifying," by J. I. Lyle; "Artificial Ice Making and Refrigeration from the Standpoint of the Central Station," by C. H. Stevens; "Refrigerating Process for Purifying Hydrochloric Acid," by A. Le Roy; "Application of Refrigeration in the Chocolate Industry," by L. Bordenave; "The Employment of Refrigerating Machines in the Austrian Paraffin Industry," by Phillip Porges; "Cryotheraphy," by Prof. Bordas; "Outdoor Artificial Ice Rinks, Their Management and Hygienic Importance," by Edward Engelman; "Refrigeration in the Perfumery Industry," by C. de Chessin Cherchevsky; "Ice Formation," by R. A. Barnes; "Cost of Manufacture in Distilled Water Ice Plants," by Peter Neff; "Application of Refrigeration in the

rewery," by A. Blanchet; "Proper Temperatures to Carry urs and Fabrics," by Albert M. Read; "A Study of Refrigertion in the Home and the Efficiency of Household Refrigration," by John R. Williams; "Refrigeration and Central tation Service," by Charles J. Carlsen.

ECTION V. RAILWAY AND STEAMSHIP REFRIGERATION

President, W. C. Brown; vice-president, C. M. Secrist; sec-tary, E. F. McPike.

Papers: "Dimensions, Proportions, Capacity and Insula-on of Refrigerator Cars," by R. H. Parks; "Organization for ransportation of Perishable Products under Refrigeration," y J. S. Leeds; "Theory and Practice of Using Ice in Transit o Prevent Freezing of Perishable Goods," by Peter Neff; Practical Means of Shifting Refrigerating Cars on Tracks f Different Gages," by A. Charron; "Transportation of Per-shable Freight on the Russian Railways," by Prof. D. N. olovine; "The Need of Uniform Regulations and Supervision f Refrigerated Transportation by Rail," by Richard Bloch; Coördination of the Efforts of the Great Steamship Com-anies and the Railroad Companies in Behalf of Refrigerated ransportation," by Richard Bloch; "Laws and Regulations elati e to the Transportation of Perishable Commodities," ichard Bloch; "Progress in France in Refrigerated Transcr tion by Sea," by Maurice Roux; "Transportation of Per-shable Goods by Barges," by Walter B. Pollock; "Relative onsideration of the Need of a Comprehensive Organization y Transportation Companies," by A. M. Mortensen; "Meth-ds of Precooling Perishable Goods," by B. W. Redfern; Handling Manufactured Ice at Icing Stations," by H. B. Vood; "Method of Protecting Perishable Freight from Loss nd Damage in Freezing Weather and the Use of the Record-ng Thermometer," by William Maclaier; "Methods of Pre-ooling Perishable Goods at Loading Points," by C. M. Sec-ist; "Facilities Maintained by Railroads for Replenishing Ice or Refrigeration in Transit," by C. M. Secrist; "Refrigeration n Ocean Steamships," by C. J. Beck; "Mechanical Traction of Merchandise and the Use of Trucks on Tramway Tracks for Running Refrigerator Cars over Tracks of Different Gage," y Emile Druart; "The Refrigeration of Dressed Poultry in ransit," by M. E. Pennington and A. D. Greenlee; "The Ad-antages of a Combination Heater and Refrigerator Car," oy V. E. Sharp; "Consideration of the Necessity of Uniform Reg-lations to Facilitate and Control the Circulation of Refrig-rator Cars in Interstate Commerce, Including Their Possible ransfer in the Loaded State to Boats Over Rivers and Other odies of Water," by H. M. Wigney; "Consideration of the leans at Present Employed in Railway Cars for Effecting efrigerated Transportation of Perishable Goods Therein," by . C. Bohn; "Frigorific Transportation by Land in the Ar-entine Republic; Its Evolution Since 1910," by Dr. Jose omas Soho; "Frigorific Transportation by Water; Its His-ory and Development from 1867 to 1913, Especially from the oint of View of the Transportation of Frozen and Refriger-ted Meats from the Argentine Republic," by Pedro Borges.

SECTION VI. LEGISLATION AND ADMINISTRATION

President, Hon. James R. Mann; vice-president, Frank A. Horne; secretary, Barry Mohun.

Papers: "Insurance Against Indirect Damage," by Albert Krueger; "The Legal Status of Cold-Storage Warehouse Receipts in the United States of America," by Albert M. Read; "Laws and Regulations Affecting the Storage of Perishable Food Products Under Refrigeration in Public and Private Warehouses," by Dr. H. E. Barnard; "Liability of Warehousemen for Loss or Damage Where Goods are Stored in Rooms to Which the Customer Alone Has Access," by Walter C. Reid; "Insurance Against Indirect Damage," by Joseph G. Hubbell; "Sprinkler Leakage as Affecting Warehousemen and Their Customers," by Joseph G. Hubbell; "Instruction in the Science and Application of Refrigeration in the United States," by S. S. Van Der Vaart, "Present Status of the Refrigerating Industries in America," by S. S. Van Der Vaart; "The Status of the Refrigeration Industry in Austria," by Prof. Alois Schwarz; "Collective Report on the Status of Instruction on Refrigeration," by Prof. Alois Schwarz; "Regulating of Cold Storage as a Means of Reconciling the Interests of Both Public Hygiene and Commerce," by M. H. Hartel; "Laws and Regulations Affecting the Transportation of Perishable Goods as to Shippers' Duty and Carriers' Liability," by Charles Conradi; "Instruction in Refrigeration in France," by Prof. L. Marchis; "Effectiveness of Existing Laws Regulating Cold Storage Warehouses and Products," by Frank A. Horne; "Instruction in Refrigerating Industries in Russia," by N. Borodin; "The Duty of the Warehouseman in View of the Requirements of the Uniform Warehouse Receipts Act in Regard to Negotiable Warehouse Receipts and of Cold-Storage Laws Prohibiting the Retention of Goods in Cold Storage for Longer Than Prescribed Periods," by Barry Mohun; "Laws and Regulations Affecting the Transportation of Perishable Goods, as to Shippers' Duties and Carriers' Liability," by Henry C. Nicholson; "The Refrigerated Meat Industry in the Argentine Republic: Its Evolution Since 1908," by Pedro Borges.

PAPERS OF GENERAL INTEREST

For the latent heat of ice, values of 141 to 144 B.t.u. per lb. have been used. A correct and uniform value the world over is of the greates importance, as on this unit all refrigerating capacities are based. As may have been noticed two papers on this subject were presented before the first section. Values of 79.63 and 79.6 calories per gram at 59 deg. F., or approximately 143.5 B.t.u. per lb., were given respectively in each paper. The value first given was determined at the Bureau of Standards, Washington, D. C., and the latter value by A. Leduc, professor at the Faculty of Sciences, Paris. Such close agreement between the two figures would indicate accuracy, so that for all practical purposes the above value might well be taken. It was left to the second section, however, to recommend to the commission of the International Association of Refrigeration the general adoption of the value 143.5 B.t.u. as the true latent heat of fusion of ice.

Of the other divisions sections II and IV were most productive of papers interesting to the power field. In the second section there were three papers on insulation, giving methods of computing the thickness required. The one by R. L. Shipman was the most complete of the three and discussed particularly the temperature line method of testing and rating insulations, which seems to give fair promise of simplicity and accuracy.

In one of his papers for this section, Gardner T. Voorhees proposed a method of compressing the exhaust steam from an engine for use in an absorption system. According to the author the generator usually requires too high a pressure to be economical in the exhaust of a steam engine. To obtain the pressure required for the most efficient operation an independent compressor is installed and by the use of 1 lb. of live steam from the boiler, 3 to 4 lb. of exhaust steam is compressed to the proper pressure and delivered to the absorber. A large increase in economy is claimed for the system. In the discussion it was brought out that practically the same method was in use in France and Switzerland over 25 years ago, and it was feared that the difficulties which the proposed arrangement would meet in actual practice might overbalance the increase in economy. In his second paper Mr. Voorhees considered the construction and economy of his multiple effect compressors and receivers.

An interesting paper on multiple effect absorption machines was presented by Edmund Altenkirch, of Berlin, and in another paper Bernard Tenchkof proposed to use the waste heat from the condenser and the engine of a compression system for hot-water heating. The heat generated in the condenser and absorber of an absorption system may also be used in the same way. Claims of a possible saving of 80 per cent, in the cost of heating were made.

A paper of exceptional interest to the practical man was that by R. H. Tait and L. C. Nordmeyer on "Comparative Installation and Operating Costs of a Combined Ice Manufacturing and Cold-Storage Plant." The base of comparison was a plant having a capacity of 60 tons of ice per day of 24 hr. and a cold-storage capacity of 100,000 cu.ft. requiring 20 tons of refrigeration or 12 tons ice-making capacity. The cost was figured first with a simple steam plant, second with a compound condensing plant and third with the Diesel engine. In the same order the comparative costs per ton of ice were $2.10, $1.97 and $1.65, giving a considerable margin in favor of the Diesel engine.

In the fourth section most of the papers naturally dealt with the application of refrigeration to the industries. There were a few, however, more closely related to the power plant. In his paper G. F. Bein discussed the possibilities and described a central plant distributing ammonia through a system of underground mains to its customers, with expansion valves at each service. Peter Neff gave some excellent data on the cost of manufacture of distilled water ice in plants of 10 to 100 tons capacity in 24 hr. The cost per ton varied from $1.42 to $2.60 depending on the size of the plant.

Service from the central station for refrigerating plants was discussed in papers by C. H. Stevens, of the Edison Electric Illuminating Co., of Brooklyn, and Charles Carlsen, of the Commonwealth Edison Co., of Chicago. In each paper an interesting collection of data was presented on plants requiring as much as 500 hp., although in most cases the connected horsepower was less than 30. The development of the raw-water plant, in which very little if any distilled water is required, has opened up opportunities for the central station which did not exist with the distilled-water plant. Some

of these papers will be abstracted at greater length in succeeding issues.

On Tuesday the sections held their last sessions, and on Wednesday morning, Sept. 24, the International Association met as a body, deciding to hold the Fourth Congress of Refrigeration in Russia. The afternoon saw the formal closing ceremonies of the Congress.

THE BANQUET

Of the varied entertainment during the Congress the banquet on Tuesday evening, Sept. 23, in the Hotel Sherman Casino, at White City, was easily the feature. It was a brilliant affair dedicated to cold storage, the articles on the menu dating back from two weeks to sixteen months. Fully 1000 sat at table and listened with interest to the speakers of the evening: Hon. William E. Mason, Senator Lawrence Y. Sherman and Hon. Andre Lebon, of Paris.

EXPOSITION

From Sept. 17 to Oct. 1 the International Exposition of Refrigeration was open to the public. It was held in the Dexter Pavilion at the stock yards and was a remarkably good exhibit. Its primary object was to create public confidence in cold storage and show that such foods are as healthful as those not subjected to refrigeration. Secondly, opportunity was given the foreign delegation to see the best in ice making and refrigerating machinery and its application as practiced in this country. There were operating and still exhibits of refrigerating machinery, engine-room equipment, appliances and specialties; exhibits of supplies and materials, exhibits by commercial interests, exhibits of refrigerator cars and precooling systems and displays of food stuffs held under refrigeration.

All the large manufacturers of compression and absorption systems had exhibits and there was a fair representation of raw-water ice-making systems. The Arctic Ice Machine Co. showed its compressors, brine cooler and condenser and a block of raw-water ice made by the Arctic-Pownall system. A small raw-water ice-making plant complete was exhibited by the Baker Ice Machine Co. The Carbondale Machine Co. had a small demonstration absorption system in actual operation taking exhaust steam at 2-lb pressure from a small generating set. A Corliss engine-driven compressor, counter-current condensers and a 20-hp. crude-oil engine formed the exhibit of the De La Vergne Machine Co. The Frick Co. had a large exhibit of horizontal and vertical compressors and its condenser, and similar exhibits of their products were displayed by the Triumph Ice Machine Co., and the York Manufacturing Co. The Vilter exhibit consisted of a 125-ton compressor direct connected to a tandem Corliss engine kept in motion by a motor belted to the flywheel. The Huetteman & Cramer Co. had a complete raw-water plant in operation. Kroeschell Bros. Ice Machine Co. displayed a 50-ton horizontal carbonic anhydride compressor and other equipment belonging to the compression system, and the Henry Vogt Machine Co. showed a 20-ton exhaust-steam absorption system. The United Ice Improvement Co. demonstrated the Parsons "Quick Freeze" system, with a tank holding eight 300-lb. ice cans.

There were numerous exhibits of packing, insulation, ammonia drums, cooling towers, piping and fittings, pumps, power-plant specialties, ice-handling machinery, evaporators, instruments, reboilers and water purifiers, ice cans, etc., besides a number of commercial displays of refrigerated products. The above, however, were too numerous to permit of individual mention.

Some of the features which attracted popular attention were liquid air demonstrations by Georges Claude, of Paris, a sculpture of a polar bear and Eskimo in refrigerated butter by the Beatrice Creamery Co., of Chicago, a mechanical oil farm showing derricks, tanks, etc., by the Standard Oil Co., the ice fountain near the entrance to the pavilion, and the Government's huge refrigerator containing displays of fruit, vegetables, meat, poultry, fish, eggs, cheese and other products.

The ice fountain was designed by Eugene T. Skinkle, of Chicago, and was made up in the form of a circular tower with pipe coils furnished by the Rempe Co., of Chicago. There were four terraces, the lowest one being 8 ft. in diameter and the others 6, 4 and 2 ft., respectively, with a ball on top 1 ft. in diameter. Brine was circulated in the coils and a coating of ice formed over the exterior. Within the fountain were located a number of colored lights of different tints, which as they were switched on produced color effects that were most pleasing and attractive.

Immediately behind the fountain was the Government's magnificient exhibit of food products. The huge refrigerator was 150 ft. long, 20 ft. wide and 18 ft. high, with display windows all the way around, so that the interior containing the various products previously mentioned was exposed to view. Pipe lofts extended above the rooms, the amount of piping being proportioned to the temperatures to be maintained in each compartment. Brine was circulated in the coils and was under full control so that the temperature might be varied at will.

It may be of interest to state that the exposition was conceived by the industry itself. No private capital had any connection with it and the profits from the sale of space and the gate receipts reverted back to the exhibitors. There was a large attendance not only of refrigerating men, but also of home people who were interested only in the consumption of refrigerated products, so it is fair to assume that the exhibition was a success and accomplished the ends sought by the industry.

Welcome to N. A. S. E. Officers

A well attended and very enjoyable welcome was tendered to the national officers of the National Association of Stationary Engineers, by the Modern Science Club, 125 South Elliot Place, Brooklyn, Tuesday evening, Sept. 29. Of the national officers of the N. A. S. E., James R. Coe, president, John J. Reddy, conductor, past national presidents, William Reynolds and Joseph Carney and J. D. Taylor, secretary of the Life and Accident Insurance Department were present. The speeches of President Coe and Conductor Reddy were well received.

Entertainment and refreshments added to the pleasure of the occasion. Those who took part in the entertainment were Herbert Self, Peerless Rubber Co., the New York Quartette consisting of John Lloyd Wilson, of Swan & Finch Co., Frank J. Corbett, now in business for himself; M. J. O'Connell, N. J. Mechanical Rubber Co. and Bob Jones, Jack Armour, of "Power," Billy Murray, Mabel Burke, Joe McKenna and Monroe Silver, all of Jenkins Bros.

Dr. Diesel Disappears

On Sept. 30, special cable dispatches to the daily press announced the disappearance of Dr. Rudolph Diesel, the inventor of the Diesel oil engine, under most mysterious circumstances. The New York "Times" says that Dr. Diesel left Antwerp on Sept. 29 to attend in London the annual meeting of the Consolidated Diesel Engine Manufacturers. He embarked on the steamer "Dresden," accompanied by a fellow-director, George Carels, and Herr Luckmann, chief engineer of the company.

Dr. Diesel had a cabin to himself. On the arrival of the vessel at Harwich at 6 o'clock a.m., he was missing. His bed had not been slept in, though his night attire was laid out on it.

It is conjectured by his friends that Dr. Diesel fell overboard. He complained to a friend some time ago that he was occasionally troubled with insomnia, and it is possible that when his friends retired to their cabins he decided to continue to stroll on deck. He was in the best of health, in very cheerful spirits, and had expressed most sanguine expectations as to the future of his engine and the development of the company.

Manning, Maxwell & Moore Purchases Putnam Machine Co.

The entire stock of the Putnam Machine Co., Fitchburg, Mass., has just been purchased by Manning, Maxwell & Moore, Inc., of New York.

The Putnam Machine Co. is the pioneer tool manufacturer of the country and was the originator and builder of the Putnam engine. S. W. Putnam, son of the founder and himself a designer of wide reputation, and his son, S. W. Putnam, will retain their connection with the company, which will keep the name of the Putnam Machine Co., and be operated on its own identity.

About the first of October, the stock of the Manning, Maxwell & Moore Co., which has heretofore been carried at 85 Liberty St., will be carried at the Jersey City distributing station, 446 Communipaw Ave., Jersey City, N. J., from which point shipments will be made. The concern has recently taken new offices of about 24,000 sq.ft. (double their present office quarters) on the twentieth and twenty-first floors of 119 West Fortieth St., New York, which will be occupied shortly after Oct. 1.

Receiver Explosion Fatal to Two

Twenty minutes after starting the 525-kw. Greene-Wheel-, cross-compound condensing engine in the plant of the aclark Wire Co., Bay Way, N. J., Monday morning, Sept. the receiver head blew out, killing two oilers and badly ening Frank B. Smith, the chief engineer.

The receiver is located below the floor, and between the gh- and low-pressure cylinders. It is provided with two fety valves, 3 and 2 in. respectively, on the exhaust line

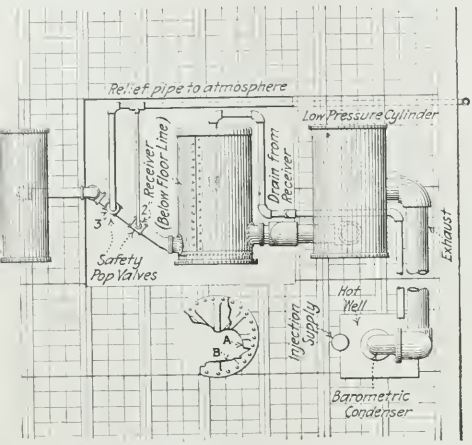


FIG. 1. PLAN OF RECEIVER PIPING

om the high-pressure cylinder. These valves are con-ected to a relief line leading outside the engine room to the mosphere as shown in Fig. 1. The engine had been started 7 a.m. and the two oilers and the watch engineer were anding between the two cylinders observing the engine un-the vacuum was built up and everything running well. tisfied that all was well, the assistant so informed the oil-s and started away. When just beyond the high-pressure linder the explosion occurred, lifting the floor as shown,

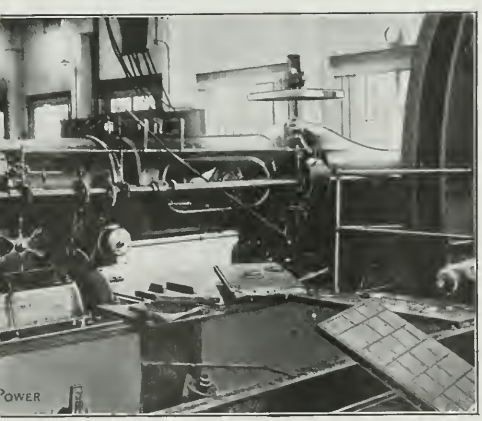


FIG. 2. FLOOR OF RECEIVER PIT BLOWN AWAY

g. 2, and almost instantly scalding the oilers to death. he chief engineer by this time had reached the throttle, but he started to close it, he saw through the dense steam, e form of one of the oilers whom he then tried to rescue. was this act of heroism that caused steam to scald the ief, as the oiler lay on the pieces of flooring directly over e broken receiver head from which steam, at boiler pres-re (145 lb.) was issuing.

The engine was carrying 2200 amp., which is about one-half rated load, at the time; the vacuum gage registered 25 in. The receiver drain pipe shown leads to the hotwell, there being no trap in the line.

There is no evidence of water having been sucked into the receiver from the hotwell through this drain pipe because of a vacuum in the receiver due to an extremely early cutoff in the high-pressure cylinder. There was no water in the receiver pit except the little from the condensed steam.

Although the wreckage could not be disturbed for examination, because prohibited by the coroner, the visible edges of the broken receiver head shows signs of having had an incipient crack between the points A and B, Fig. 1. The metal here exhibits deep red rust in places and is of a different color from the other parts of the break which appear dark gray and fresh. As there was no undue amount of water present, and conditions show that the low-pressure admission valve operated, and as the cast-iron head of the receiver indicates weakness, one reaches the conclusion that one of the admission valves was held open, admitting steam at initial pressure to the receiver, and that the safety valves failed to operate until simultaneously or nearly so with the explosion of the receiver That they operated is evidenced by the presence of fine rust on the ground at the mouth of the relief pipe. These valves were set to blow at 30 lb. pressure.

PERSONALS

E. A. Stierly has been appointed chief engineer of power station of the Newport News & Old Point Comfort Ry. & Electric Co., at Hampton, Va., succeeding H. I. Holleman.

William J. Neville has been appointed manager of the Southern territory of the Chapman Valve Manufacturing Co. with offices in the Candler Building, Atlanta, Ga. For the past two years the company had its offices in Birmingham, Ala.

SOCIETY NOTES

At the last annual convention of the Practical Refrigerating Engineers Association, at Atlanta, Ga., in December, 1912, Hot Springs, Ark., was named as the place for the 1913 convention. Since that time, circumstances have arisen which caused the board of directors and officials to consider some other place for the convention. It was finally decided that Dallas, Texas, would best serve the interests of the association under the circumstances. Preparations are being made to make this convention interesting and successful.

OBITUARY

SETH C. ADAMS

Seth Collins Adams, an electrical engineer, connected with the Westinghouse Electric & Manufacturing Co., at New York City, died at his home in Rochelle Park, New Rochelle, N. Y. Mr. Adams was born in 1866 and was a graduate of Hamilton College.

WILLIAM C. SELDEN

William Cary Selden, a consulting mechanical engineer, who had much to do with the early development of steam navigation in the United States Navy, died at his home, 313 Washington Ave., Brooklyn. He was eighty-one years old, but had been active in his profession until last summer, when his health began to fail.

GEORGE C. KARME

George C. Karme, secretary of the Hills-McCanna Co., manufacturers of steam specialties, 153 West Kinzie St., died suddenly on Sept. 21, in his office, supposedly of heart disease. Mr. Karme appeared at 9 o'clock in the morning and announced that he had planned a hard day's work and did not wish to be disturbed. A half hour later a clerk said he saw Mr. Karme at the office door beckoning to him. He was gasping for breath. The clerk obtained brandy at a drug store and called a physician, but Mr. Karme died within fifteen minutes, before medical aid could reach him.

POWER

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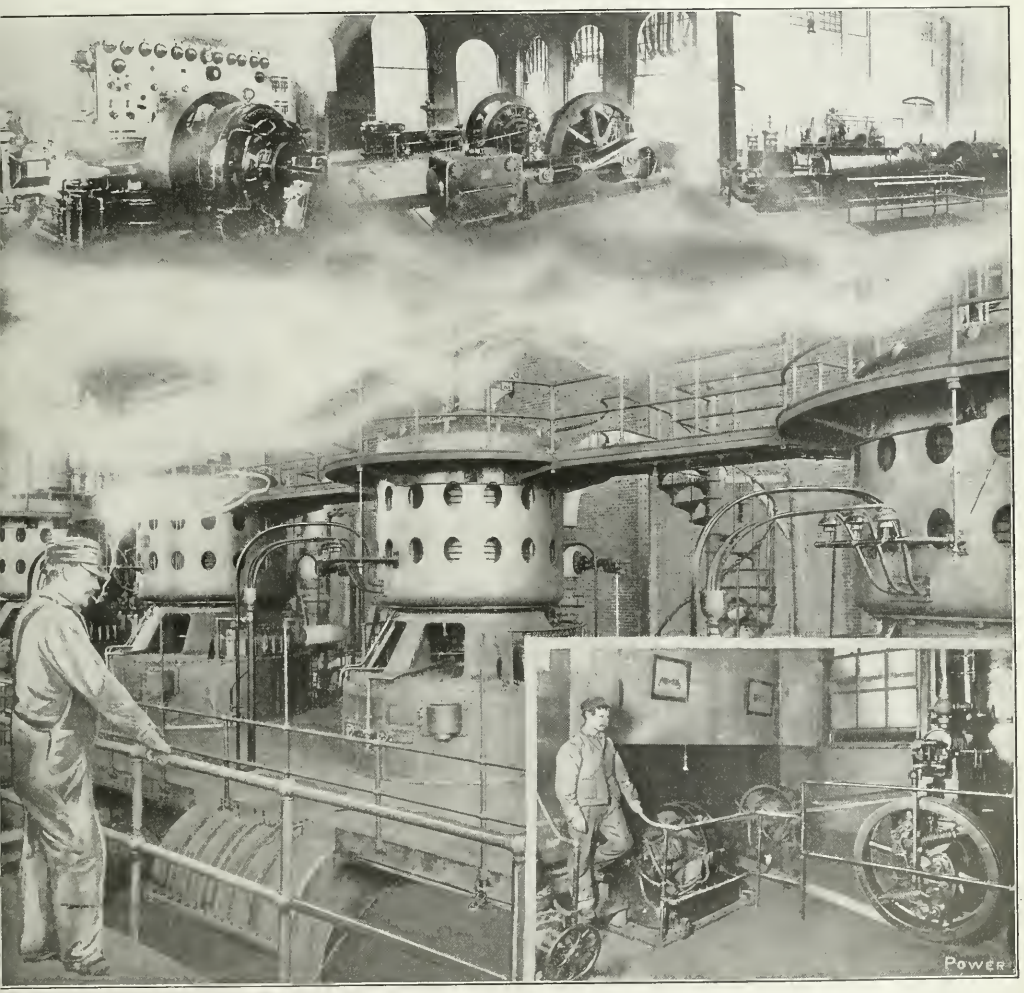
Engineering Progress



THESE TWO ENGINEERS HAD THE SAME OPPORTUNITY: ONE STOOD STILL, THE OTHER PROGRESSED FROM THE SMALL TO THE LARGE POWER PLANT.

Boiler Plant of American Sugar Co.

By Ernest F. Learned

NOPSIS—The recently completed boiler plant of e American Sugar Refining Co.'s refinery at South ston, Mass., was designed with storage facilities for 00 tons of coal, and an ultimate capacity of 10,160 . Some of the features are the design of the struc- re on a limited site providing for the storage of the l above the boiler room; unusual natural lighting; protection from heat of the columns supporting the l bin in the boiler room, and the use of cement-gun ncrete in the upper part of the building.

The plant, consisting of a boiler room and a coal cket, adjoins a dock bordering the entire length of e company's property along Fort Point Channel, an m of Boston Harbor, and is inclosed on three sides by ildings. The structure is 170 ft. long, about 98 ft. de, and 101½ ft. high. It is of fireproof construction, ilt of concrete, steel and tile blocking, and is sup- rted on reinforced-concrete foundations carried on les cut off 6 ft. above mean low water. The boiler om, occupying the main story of the building, is 32 6 in. in height, its floor being 11 ft. above the level the grounds.

The coal pocket is located on a longitudinal axis di- ctly above the boiler room, and is 48 ft. wide, 26 ft. gh on the sides and 35 ft. 6½ in. at the ends. The wer chords of the roof trusses are carried 23 ft. 6 in. above the top of the bin, allowing a distance of 7 ft. over the peak of the coal when the bin is filled to its capacity. The full width of the building extends for a distance of 103½ ft., the remaining portion at the dock end of the structure being equal in width to the coal pocket.

Fig. 1. View of the Boiler Room, Showing Traveling Weigh Hopper

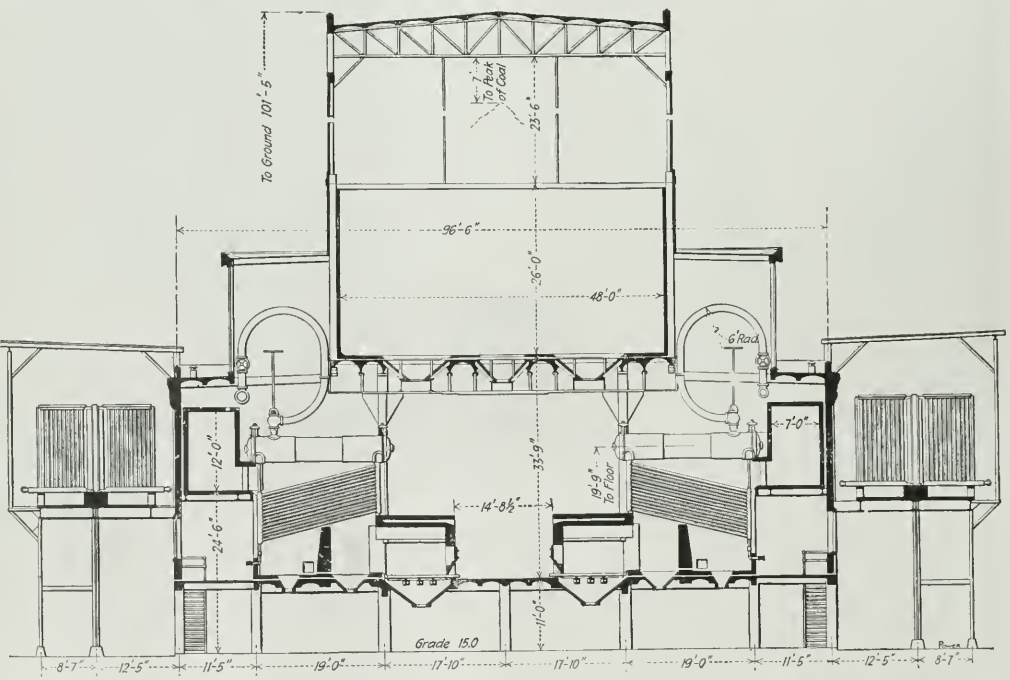


Fig. 2. Elevation of the Boiler Room

The boiler equipment, Fig. 1, consists of twelve 508-
). Babcock & Wilcox water-tube boilers based on 5086
q.ft. of heating surface with a ratio of 10 to 1. The
oilers are built in batteries of two units each, arranged
two rows facing a single firing aisle 14 ft. 8½ in.
ide, the total capacity being 6096 hp. Additional space
or four batteries of 1016 hp. each, two on either side,
aking an ultimate boiler capacity of 10,160 hp., can be
otained by widening the boiler room at its narrow end
its full width. The working boiler pressure is 125
id 80 lb. About 75 per cent. of the steam is used for
ommercial purposes, the remainder being utilized for
ower.

The foundations are about 8½ ft. deep and vary in
ea from 8 ft. square to 17x21 ft., the latter supporting

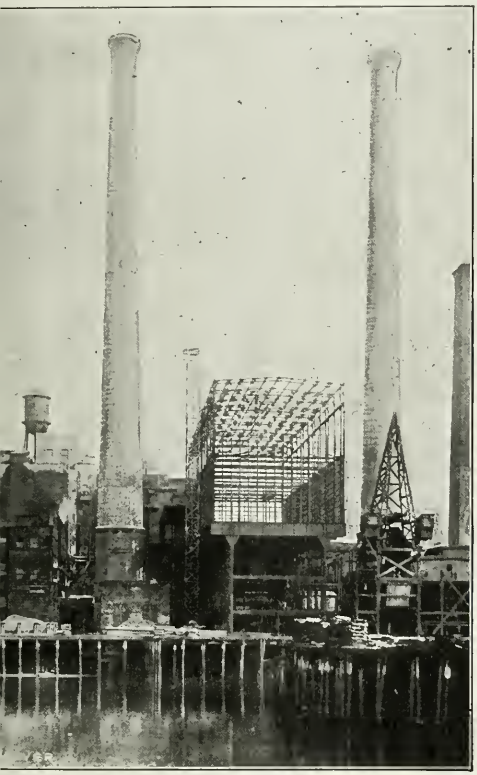


FIG. 3. VIEW OF THE STEEL FRAMEWORK OF THE BOILER HOUSE

o columns. The maximum column load is 467 tons,
id is carried on a 13x21-ft. foundation. There are two
imneys, each serving a row of boilers, located midway
tside the building adjacent to the side walls. The
imneys are 275 ft. high, 12 ft. in diameter at the top
id 15 ft. 8 in. at the base, inside measurements; made
Custodis radial brick; and each rests on a reinforced-
ncrete foundation 41 ft. square and 10 ft. deep, carried
400 piles.

The transverse column spacing divides the structure generally into bays 5 ft. 10 in. and 13 ft. 4 in. wide, the smaller being between the boiler batteries, and the larger between the units in a battery.

There are seven longitudinal rows of columns under the main portion of the boiler room, two rows on either side of the center line support the girders carrying the coal pocket. The columns are built of steel encased in

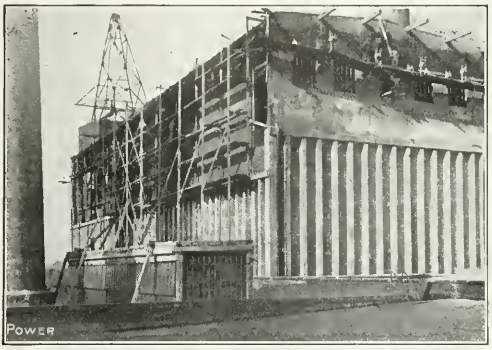


FIG. 4. CONCRETE COVERED COAL POCKET

concrete, except those in the boiler room near the boilers.

The sides of the boiler room not occupied by the windows and columns are inclosed with fireproof tile blocking. The floor is of concrete, arched and supported by I-beams.

In order to provide for natural lighting the coal pocket was built 8 ft. above the boilers, enabling light to pass through the windows on the sides of monitor roofs located on either side of the structure along the lower portion of the coal bin. The windows are 13½x5½ ft. in size, of continuous sash, fitted with wired glass. The expansion loops from the boilers supplying the main header are carried up into the monitor roof, Fig. 2, and the wheel stop valves at either end of the loops can be closed from one position, as the valves attached to the boilers are provided with extension shafts.

A typical girder is 51 ft. 8½ in. long, 5 ft. deep, built of ⅞-in. web plate, 8 and 8 by ⅞-in. angles and 20x½-in. flange plates. These girders act as cantilevers on account of the supporting columns being placed 8 ft. from the ends.

Each boiler equipment includes three reinforced ash hoppers, one being located under the furnace and two under the boiler, as shown in Fig. 2.

On account of the limited space it was necessary to locate the columns within the front line of the boilers in the rear of the Murphy furnaces between the units of a battery, and in order to sufficiently protect the columns from the heat, a 2-in. air space was provided on all sides.

The sides and ends of the bin consist of H-columns and channels placed vertically with T-irons laid horizontally, covered with poultry wire and embedded in a wall of concrete 2 in. thick on each side of the steel.

There are three coal hoppers in each large transverse bay of the bin, making a total of 51 hoppers serving the coal pocket. The coal and ash hoppers are fitted with undercut gates. One row of hoppers is located along the center line of the building, and the other two are about

3 ft. on either side of the center. The steel work between the girders in the narrower bays consists of thirteen 10-in. I-beams spaced generally about 3 ft. 4 in. on centers, and in the larger bays the steel work consists of groups of four longitudinal and four transverse I-beams spaced symmetrically about the hopper locations. The floor, with the exception of the hoppers, is composed of corrugated-iron arches, covered with 7 in. of reinforced concrete. Two 12-in. channels located above each girder tie the sides of the bin at the top. Fig. 5 shows the steel framework of the building.

The roof trusses are carried on H-columns about 28 ft. above the top of the bin, and the sides are inclosed with a 2-in. coating of cement-gun concrete or "gunite" driven against a reinforcement of No. 28 core mesh from the nozzles of a cement gun. The mesh was attached to the columns and to three 5-in. I-beams placed longitudi-

FIG. 5. GENERAL VIEW OF PLANT, SHOWING FUEL-HANDLING APPARATUS

ally between the former. The cement gun working under pressure of 30 lb. per sq.in. applied the "gunite" composed of one part cement and three parts sand to both sides of the mesh, 1-in. coating on either side. Windows are provided in the upper part of the structure on three sides near the roof, Fig. 4. An advantage in the use of "gunite" is that the column loads are lighter than if the sides were inclosed with tile blocking, such as employed in the lower portion of the building. At the end of the building adjoining the dock there is a 10x14-ft. opening in the upper wall, through which a Robins 30-in. coal conveyor passes from a Procter unloading tower erected on the dock. The roof is reinforced concrete arched between I-beams and covered with tar and gravel. The unloading tower, Fig. 5, designed for a capacity of 150 tons per hour, is equipped with Meade-Morrison duplex engines and a 1¼-ton clamshell bucket. The sizes of the cylinders of the hoisting and trolley engines are 14x24 in. and 10x12 in. respectively. The boom is 124 ft. above the dock and is one of the highest in New England.

The boilers supply steam to the engines through a 5-in. line. The coal is discharged from the bucket into a hopper equipped with a No. 7 Hunt coal crusher reducing its size to 2 in. A Morrick weightometer is installed in the rear of the hopper on a 30-in. conveyor extending the entire length of the coal pocket. The conveyor, suspended from the lower chord of the roof trusses and furnished with a hand tripper, is belt driven at the rate of 400 ft. per min. by a 15-hp., 220-volt, three-phase, 60-cycle motor. The capacity of the conveyor is 150 tons per hour.

Coal is supplied to the furnaces from the bins by means of a 5-ton traveling weigh-hopper running on a track supported by the columns carrying the main girders of the upper part of the structure, as shown in Fig. 1. The weigh-hopper is equipped with a 7.5-hp., 220-volt, alternating-current motor for the longitudinal travel, and with a 2.5-hp. motor for the transverse travel; the respective speeds being 175 and 35 ft. per min. The arrangement of the hoppers and the weigh-hopper permits coal to be taken from any part of the bin and fed to any furnace, thus enabling the removal of the coal regularly from all parts of the bin, and preventing continued storage over an idle boiler and the possibility of an excessive rise in temperature causing spontaneous combustion. The bin can be emptied with the exception of 300 tons without trimming by hand shoveling.

Each row of boilers is provided with a flue and economizer. The flues are of brick 7x12 ft. in section supported on steelwork, extending along the rear of the boilers; and at one end swing outward and run parallel to the sides of the building to the stacks. The economizers are located within the flues near the stacks and consist of two sets of 36 sections, 10 tubes in width. Provision is made for bypassing the flue gases around the economizers. The plant was designed and built by the American Sugar Refining Co., under the direction of F. M. Gibson, chief engineer.

Novel Ash-Handling System

Most coal- and ash-handling machinery is intermittent in its operation, because the storage for coal is generally provided on the boiler-house floor or in bins; ashes are allowed to accumulate in ashpits until a con-

FIG. 1. LINK BELT ASH CONVEYOR

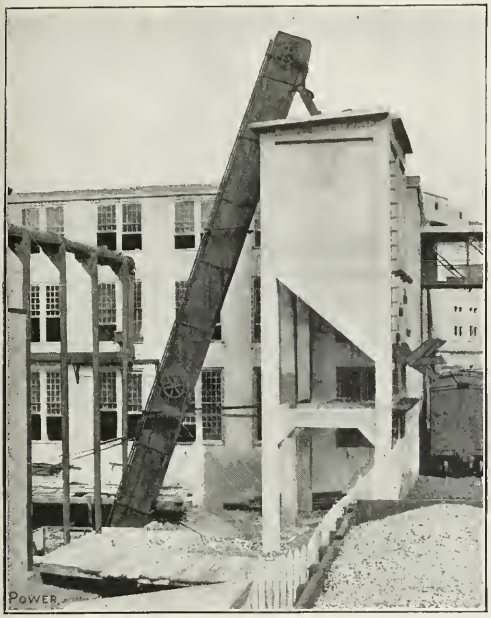


FIG. 2. ASH ELEVATOR DISCHARGING TO CONCRETE ASH BIN

venient time comes to remove them. There are cases, however, where it may be necessary to run the machinery continuously, and to provide against serious wear and rapid deterioration, special designs are necessary.

At the main boiler house of Joseph Bancroft & Sons Co., Wilmington, Del., the ashes which dropped continuously from the stoker grates were allowed to accumulate in a tunnel under the boilers, the tunnel being 11x13 ft. in section, large enough for a horse and cart to go through. In 1911 the boiler house was made longer, and it was decided to install an ash conveyor to remove the ashes from the tunnel as fast as they were dropped, and store them in a bin at one end of the boiler house. This would dispense with the labor of two men and a horse and cart.

In designing the ash-handling machinery, the contractors, the Link-Belt Co., decided to use extremely slow speeds of travel, and to make the parts simple and rugged, so as to show durability while running 24 hours a day.

The ash conveyor, Fig. 1, which runs the length of the ash tunnel, 190 ft., is extremely simple. It consists of a single strand of wide link-belt traveling in a cast-iron trough at 5 ft. per min. The ashes fall from the grates into the lower run, and an empty run slides back overhead. At the end of the run the ashes drop into the boot of an elevator, 84 ft. high, Fig. 2. This elevator travels but 20 ft. per min., and has two strands of Ley Steel-Bushed Chain with heavy malleable-iron buckets. In order to make the buckets discharge at such a slow speed, there are deflector wheels at the head which invert the buckets directly over the head chute. This chute leads to a 4500-cu.ft. reinforced-concrete bin. The steel casing of the elevator carries the weight of all the machinery.

In spite of the difficulties of the service, the ash machinery has shown very little wear, and repairs have been slight. Similar plants have since been erected at other points.

Standard for Flanges and Flanged Fittings

The use of flanges and flanged fittings has been increasing quite rapidly of late years, in fact, a flange joint is the standard form of connection in many classes of piping. For most purposes the ordinary screw connection should not be used above 6-in. pipe size on account of the difficulty of making and breaking joints.

As the flange-fitting business grew, each manufacturer made up patterns for whatever sizes were called for, to his own personal ideas or knowledge at that time.

These dimensions were later published in catalogs and a wide variation in dimensions was found.

The variation in the diameter and thickness of flanges as well as the bolt circle, size and number of bolts on standard-weight material caused the users and manufacturers considerable confusion and expense.

This brought about the movement by the American Society of Mechanical Engineers and the Master Steam and Hot Water Fitters Association, assisted by the manufacturers of these lines, the result of which was the adoption of what is known as the A. S. M. E. Standard of 1894. This covered flange dimensions and bolting only.

A few years later the manufacturers began to realize that the extra-heavy 250-lb. flanges and bolting were in the same state of confusion. This resulted in the adoption of what has been known as the Manufacturers Standard of 1901.

It became evident in the past few years that the center-to-face and face-to-face dimensions of all flange fittings, including low pressure, standard pressure and extra-heavy pressure, should be established. After considerable work on the part of the M. S. and H. W. F. A. and the A. S. M. E. a standard known as the 1912 U. S. Standard was adopted.

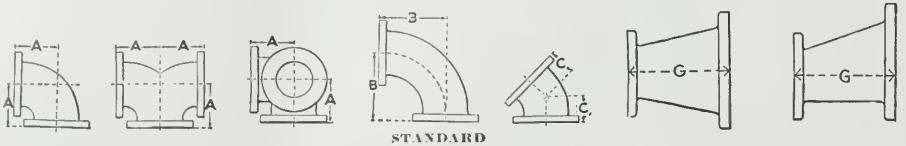
The adoption of this standard opened a discussion among those interested in the subject. It was found that the dimensions presented in the 1912 U. S. Standard differed from the dimensions which had been quite universally used by manufacturers and which covered a large majority of the fittings made.

At a meeting of manufacturers held in New York City, July, 1912, a standard known as the Manufacturer's Standard was adopted by them.

This left the flange-fitting subject in the unfortunate position of there being two standards. When this condition came before the committee of the A. S. M. E., an effort was made by this committee with that of the manufacturer's committee to harmonize, if possible, the differences then existing between these two standards.

After considering the various phases of the subject covering uniformity of design, strength of fitting, strength of bolting as well as the commercial features, a compromise was made.

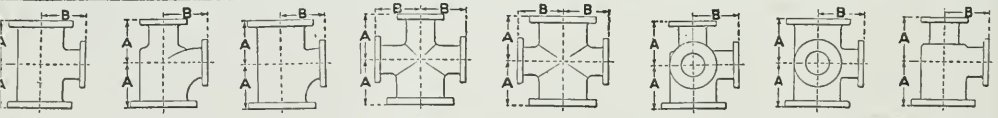
The New American Standard fo



STANDARD

Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24	26	28	30	32	34	36	38	40
A-Face to Face, Tees and Crosses	7	7½	8	9	10	11	12	13	14	15	16	17	18	20	22	24	28	29	30	33	36	40	44	46	48	50	52	54	56	58	60
B-Center to Face, Ells, Tees and Crosses	3½	3½	4	4½	5	5½	6	6½	7	7½	8	8½	9	10	11	12	14	14½	15	16½	18	20	22	23	24	25	26	27	28	29	30
C-Center to Face, Long Radius Ells	5	5½	6	6½	7	7½	8½	9	9½	10½	11½	12½	14	15½	16½	19	21½	22½	24	26½	29	31½	34	36½	39	41½	44	46½	49	51½	54
D-Center to Face 45° Ells	1½	2	2½	2½	3	3	3½	4	4	4½	5	5½	5½	6	6½	7½	7½	8	8	8½	9½	10	11	13	14	15	16	17	18	19	20
E-Face to Face Laterals	7½	8	9	10½	12	13	14½	15	15½	17	18	20½	22	24	25½	30	33	34½	36½	39	43	46	49½	53	56	59					
F-Center to Face Laterals	5½	6½	7	8	9½	10	11½	12	12½	13½	14½	16½	17½	19½	20½	24½	27	28½	30	32	35	37½	40½	44	46½	49					
G-Center to Face Laterals	1½	1½	2	2½	2½	3	3	3	3	3½	3½	4	4½	4½	5	5½	6	6	6½	7	8	8½	9	9	9½	10					
H-Face to Face Reducers						6	6½	7	7½	8	9	10	11	11½	12	14	16	17	18	19	20	22	24	26	28	30	32	34	36	38	40
Diameter of Flanges	4	4½	5	6	7	7½	8½	9	9½	10	11	12½	13½	15	16	19	21	22½	23½	25	27½	29½	32	34½	36½	38¾	41¼	43½	46	48½	50¾
Thickness of Flanges	7/16	1/2	9/16	5/8	11/16	3/4	13/16	15/16	15/16	15/16	1	1 1/16	1 1/16	1 1/4	1 5/16	1 7/16	1 5/8	1 3/4	1 7/8	2	2 1/16	2 1/8	2 1/4	2 5/16	2 7/16	2 1/2	2 5/8	2 11/16	2 13/16	2 15/16	3
Minimum Metal Thickness of Body	7/16	7/16	7/16	7/16	7/16	7/16	7/16	1/2	1/2	5/8	5/8	5/8	11/16	3/4	7/8	7/8	7/8	7/8	1	1 1/16	1 1/8	1 3/16	1 1/4	1 5/16	1 3/8	1 7/16	1 1/2	1 9/16	1 5/8	1 11/16	1 3/4

Size	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
A-Face to Face, Tees and Crosses	62	64	66	68	70	74	78	82	84	88	90	94	96	100	102	106	108	112	116	118	120	124	126	130	134	136	138	142	146	148
B-Center to Face Ells, Tees and Crosses	31	32	33	34	35	37	39	41	42	44	45	47	48	50	51	53	54	56	58	59	60	62	63	65	67	68	69	71	73	74
C-Center to Face, Long Radius Ells	56½	59	61½	64	66½	69	71½	74	76½	79	81½	84	86½	89	91½	94	96½	99	101½	104	106½	109	111½	114	116½	119	121½	124	126½	129
D-Center to Face 45° Ells	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
H-Face to Face Reducers	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
Diameter of Flanges	53	55½	57½	59½	61½	64	66½	68¾	71	73	75¼	78	80	82½	84½	86½	88½	90½	93	95½	97½	99½	102	104½	106½	108¾	111	113½	115½	117½
Thickness of Flanges	2½	2½	2 11/16	2½	2½	2⅞	3	3	3 1/16	3 1/16	3 1/16	3 1/16	3 1/8	3 1/8	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	4	4	4 1/16	4 1/16	4 1/16	4 1/16	4 1/8	4 1/8
Minimum Metal Thickness of Body	1 13/16	1 7/8	1 15/16	2	2 1/16	2 1/16	2 3/16	2 1/16	2 1/16	2 7/16	2 1/16	2 1/16	2 1/16	2 1/16	2 1/16	2 13/16	2 1/16	2 15/16	3	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16	3 1/16



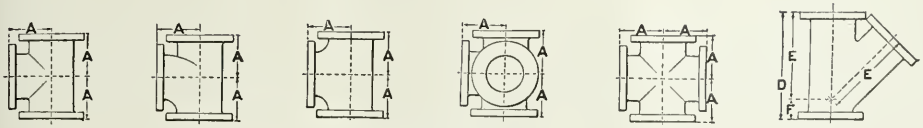
Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24	26	28	30	32	34	36	38	40
*Size of Outlet and Smaller	All reducing fittings 1" to 9" inclusive have the same center to face dimensions as straight size fittings.														6	8	9	9	10	12	14	15	16	18	18	20	20	22	24	24	26
AA-Face to Face, Run															18	20	22	23	24	26	28	28	30	32	32	36	36	38	40	40	44
A-Center to Face, Run															9	10	11	11½	12	13	14	14	15	16	16	18	18	19	20	20	22
B-Center to Face, Outlet															9½	11	13	13½	14	15½	17	18	19	20	21	23	24	25	26	28	29

Size	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72	74	76	78	80	82	84	86	88	90	92	94	96	98	100
Size of Outlet and Smaller	28	28	30	32	32	34	36	36	38	40	40	42	44	44	46	48	48	50	52	52	54	56	56	58	60	60	62	64	64	66
AA-Face to Face, Run	46	46	48	52	52	54	58	58	62	66	66	68	70	70	74	80	80	84	86	88	88	94	94	96	100	100	104	106	106	110
A-Center to Face, Run	23	23	24	26	26	27	29	29	31	33	33	34	35	35	37	40	40	42	43	43	44	47	47	48	50	50	52	53	53	55
B-Center to Face, Outlet	20	31	33	34	35	36	37	39	40	41	42	44	45	46	47	48	49	50	52	53	54	56	57	58	61	62	63	64	65	67

Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15
*Size of Outlet and Smaller	All reducing fittings 1" to 9" inclusive have the same center to face dimensions as straight size fittings.														6	8	9	9
AA-Face to Face, Run															18	21	23	23
A-Center to Face, Run															9	10½	11½	11½
B-Center to Face, Outlet															11	12½	14	15

Size	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
*Size of Outlet and Smaller	10	12	14	15	16	18	18	20	20	22	24	24	26	28	28	30	32
AA-Face to Face, Run	25	28	31	33	34	38	38	41	41	44	47	47	50	53	53	55	58
A-Center to Face, Run	12½	14	15½	16½	17	19	19	20½	20½	22	23½	23½	25	26½	26½	27½	29
B-Center to Face, Outlet	15½	17	18½	20	21½	23	24	25½	26½	28	29½	30½	31½	33½	34½	35½	37½

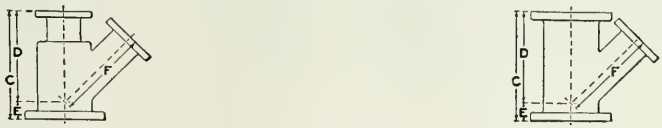
anges and Flanged Fittings



EXTRA HEAVY

Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15
AA-Face to Face, Tees and Crosses	8	8½	9	10	11	12	13	14	15	16	17	18	20	21	23	26	30	31
A-Center to Face, Ells, Tees and Crosses	4	4½	4½	5	5½	6	6½	7	7½	8	8½	9	10	10½	11½	13	15	15½
B-Center to Face, Long Radius Ells	5	5½	6	6½	7	7½	8½	9	9½	10¼	11½	12½	14	15½	16½	19	21½	22½
C-Center to Face 45° Ells	2	2½	2½	3	3½	3½	4	4½	4½	5	5½	6	6	6½	7	8	8½	9
D-Face to Face, Laterals	8½	9½	11	11½	13	14	15½	16½	18	18½	21½	23½	25½	27½	29½	33½	37½	39½
E-Center to Face, Laterals	6½	7½	8½	9	10½	11	12½	13½	14½	15	17½	19	20½	22½	24	27½	31	33
F-Center to Face, Laterals	2	2½	2½	2½	2½	3	3	3	3½	3½	4	4½	5	5	5½	6	6½	6½
G-Face to Face, Reducers						6	6½	7	7½	8	9	10	11	11½	12	14	16	17
Diameter of Flanges	4½	5	6	6½	7½	8½	9	10	10½	11	12½	14	15	16½	17½	20½	23	24½
Thickness of Flanges	11/16	13/16	13/16	7/8	1	1⅛	1 3/16	1¼	1 5/16	1⅜	1 7/16	1½	1⅝	1¾	1⅞	2	2¼	2 5/16
Minimum Metal Thickness of Body	⅜	⅜	⅜	⅜	7/16	½	½	9/16	9/16	5/8	5/8	¾	¾	13/16	⅞	1	1⅛	1 3/16

Size	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
AA-Face to Face, Tees and Crosses	33	36	39	41	45	48	52	55	58	61	65	68	71	74	78	81	84
A-Center to Face, Ells, Tees and Crosses	16½	18	19½	20½	22½	24	26	27½	29	30½	32½	34	35½	37	39	40½	42
B-Center to Face, Long Radius Ells	24	26½	29	31½	34	36½	39	41½	44	46½	49	51½	54	56½	59	61½	64
C-Center to Face 45° Ells	9½	10	10½	11	12	13	14	15	16	17	18	19	20	21	22	23	24
D-Face to Face, Laterals	42	45½	49	53	57½												
E-Center to Face, Laterals	34½	37½	40½	43½	47½												
F-Center to Face, Laterals	7½	8	8½	9½	10												
G-Face to Face, Reducers	18	19	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
Diameter of Flanges	25½	28	30½	33	36	38½	40½	43	45½	47½	50	52½	54½	57	59½	61½	65
Thickness of Flanges	2½	2½	2½	2½	2½	2 1/16	2 1/16	3	3⅛	3⅛	3⅛	3 5/16	3 5/16	3 5/16	3¼	3¼	4
Minimum Metal Thickness of Body	1½	1⅝	1½	1 11/16	1⅝	1 13/16	1 15/16	2	2⅛	2⅛	2⅛	2 5/16	2 5/16	2 7/16	2 7/16	2½	3



STANDARD

Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24	26	28	30
*Size of Branch and Smaller	All reducing fittings 1-3½" inclusive have same center to face dimensions as straight size fittings.							2½	2½	3	3	3½	4	4½	5	6	7	7	8	9	10	10	12	12	14	15
C-Face to Face, Run								13	13	14	15	16	16	17	18	20	22	23	24	26	28	29	32	35	37	39
D-Center to Face, Run								11	11	12	13½	14½	14½	15½	17	19	21	22	23	25	27	28½	31½	35	37	39
E-Center to Face, Run								2	2	2	1½	1½	1½	1½	1	1	1	1	1	1	1	1	½	½	0	0
F-Center to Face, Branch								11	11	12	13½	15	15½	16½	18	20½	23	24	25½	27½	29½	31½	34½	38	40	42

EXTRA HEAVY

Size	1	1¼	1½	2	2½	3	3½	4	4½	5	6	7	8	9	10	12	14	15	16	18	20	22	24
*Size of Branch and Smaller	All reducing fittings 1-3½" inclusive have same center to face dimensions as straight size fittings.							2½	2½	3	3	3½	4	4½	5	6	7	7	8	9	10	10	12
C-Face to Face, Run								14	15	16	17	18	20	21	23	26	29	30	32	34	37	40	44
D-Center to Face, Run								12	12½	13½	14½	15½	17½	18½	20½	23½	26½	27½	29	31	34	37	41
E-Center to Face, Run								2	2½	2½	2½	2½	2½	2½	2½	2½	2½	2½	3	3	3	3	3
F-Center to Face, Branch								13	13½	14½	15½	16½	18½	19½	21½	24½	27½	28½	30½	32½	36	39	43

THE DIMENSIONS GIVEN ABOVE ARE THOSE ADOPTED AS A COMPROMISE BY THE COMMITTEES RESPONSIBLE FOR THE "U. S. 1912 STANDARD" AND THE COMPETING "MANUFACTURERS STANDARD."

FOR EXPLANATION SEE PAGES 527 AND 530

In this compromise the bolting was increased where it was thought necessary. Additional size flanges were added and the center-to-face and face-to-face dimensions were altered to conform to these requirements.

Explanatory Notes

(1) Standard and extra-heavy reducing elbows carry same dimensions center to face as regular elbows of largest straight size.

(2) Standard and extra-heavy tees, crosses and laterals, reducing on run only, carry same dimensions face to face as largest straight size.

(3) If flanged fittings for lower working pressure than 125 lb. are made, they shall conform in all dimensions except thickness of shell, to this standard and shall have the guaranteed working pressure cast on each fitting. Flanges for these fittings must be standard dimensions.

(4) Where long-radius fittings are specified, it has reference only to elbows which are made in two center-to-face dimensions and to be known as elbows and long-radius elbows, the latter being used only when so specified.

(5) All standard-weight fittings must be guaranteed for 125 lb. working pressure and extra-heavy fittings for 250 lb. working pressure, and each fitting must have some mark cast on it indicating the maker and guaranteed working steam pressure.

(6) All extra-heavy fittings and flanges to have a raised surface of $\frac{1}{16}$ in. high inside of bolt holes for gaskets. Standard-weight fittings and flanges to be plain faced. Bolt holes to be $\frac{1}{8}$ in. larger in diameter than bolts. Bolt holes to straddle center line.

(7) Size of all fittings scheduled indicates inside diameter of ports, except for extra-heavy fittings 14 in. and larger when the port diameter is $\frac{3}{4}$ in. smaller than nominal size.

(8) The face-to-face dimension of reducers, either straight or eccentric, for all pressures, shall be the same face to face as given in table of dimensions.

(9) Square-head bolts with hexagonal nuts are recommended. For bolts, $1\frac{5}{8}$ in. diameter and larger, studs with a nut on each end are satisfactory. Hexagonal nuts for pipe sizes 1 to 46 in. on 125-lb. standard, and 1 to 16 in. on 250-lb. standard can be conveniently pulled up with open wrenches of minimum design of heads. Hexagonal nuts for pipe sizes 48 to 100 in. on 125-lb., and 18 to 48 in. on 250-lb. standards, can be conveniently pulled up with box wrenches.

(10) Twin elbows, whether straight or reducing, carry same dimensions center to face and face to face as regular straight size ells and tees. Side outlet elbows and side outlet tees, whether straight or reducing sizes, carry same dimensions center to face and face to face as regular tees having same reductions.

(11) Bullhead tees or tees increasing on outlet, will have same center-to-face and face-to-face dimensions as a straight fitting of the size of the outlet.

(12) Tees and crosses 9 in. and down, reducing on the outlet, use the same dimensions as straight sizes of the larger port. Size 10 in. and up, reducing on the outlet, are made in two lengths, depending on the size of the outlet as given in the table of dimensions. Laterals $3\frac{1}{2}$ in. and down, reducing on the branch, use the same dimensions as straight sizes of the larger port.

(13) Sizes 4 in. and up, reducing on the branch, are made in two lengths, depending on the size of the branch as given in the table of dimensions. The dimensions of reducing flanged fittings are always regulated by the reductions of the outlet or branch. Fittings reducing on the run only, the long-body pattern will always be used. Y's are special and are made to suit conditions. Double sweep tees are not made reducing on the run.

(14) Steel flanges, fittings and valves are recommended for superheated steam.

Ten-Foot Flywheel Explodes

The accompanying illustrations show the result of a recent flywheel explosion at the power house of the Lawrence Paper Manufacturing Co., Lawrence, Kan. The engine was a 14x36-in. horizontal rolling-mill type, simple noncondensing and ran normally at 120 r.p.m.

The Remains of the 10-Ft. Flywheel

It is right hand, is belted forward and runs under. The 10-ft. flywheel was built in two sections, with a 21-in. face and weighed 9300 lb.

The governor is of the center-weight type and has an automatic stop.

The accident occurred at 10:15 p.m. One piece of the rim, weighing 822 lb., was thrown through the roof and landed 225 ft. distant. Another piece, weight 550 lb., was thrown forward through the engine-room brick wall, up through the roof of the dryer room, across the railway track, coming down in the corrugation department, a distance of 200 ft. This piece fell through a bench where several girls work during the day. Other pieces were found around the engine room. The total weight of all the pieces recovered was 8140 lb.

Some idea of the speed of the engine may be had from the fact that both arms holding the governor weights were bent out at an angle of 45 deg. from the original direction.

It is presumed that the governor was coupled short and could not shorten the cutoff when the load decreased. Fortunately, no one was injured.

Condenser-Tube Corrosion

SYNOPSIS—The lasting quality of condenser tubes is found to depend more upon their microstructure than upon their chemical composition. Slow annealing at a temperature of not over 400 C. after hard drawing produces a close metal of uniform grain which will greatly outlast untreated tubes of the same material.

The committee on steam turbines of the Association of Edison Illuminating Companies, of which committee J. P. Sparrow, chief engineer of the New York Edison Co., is chairman, submitted a report to the annual convention recently held at Cooperstown, N. Y., which contains the most satisfactory and promising treatment of the causes of corrosion in condenser tubes which has come to our knowledge.

The committee classifies tube troubles into three groups:

First—Split or cracked tubes.

Second—Pitted tubes.

Third—More or less complete dezincification resulting in brittle tubes.

The committee assumes that the formerly prevalent idea that corrosion was due to electrolytic action of stray outside currents is no longer given weight, but that local galvanic action set up in the constituents of the alloy by the presence of an electrolyte is the only reasonable explanation of condenser-tube deterioration.

Split tubes are caused by improper mill treatment, either of drawing or annealing. A hard-drawn tube has internal strains, which in many cases results in a split before the tube is placed in service. Cracks at right angles to the axis of the tube may occur when the tube is subject to constant deflection, due to improper support, by vibration, due to steam impact, and consequent hammering on supporting plates, or by constant deflection and rotation, due to friction of steam on the tube surface.

It is practically the unanimous opinion of manufacturers that split tubes may be avoided if the user will accept tubes of the proper temper.

The results of observations made upon tubes in service, and of accelerated corrosion tests, have recently led to the belief that the micro-structure of the alloy had a greater bearing on the corrosion and life of the tube, than the actual composition of the alloy itself. A batch of tubes from one mill, and produced as one lot, would have various lengths of life according to their grain size and hardness.

This fact led to an investigation of the composition, structure and mill treatment of the tubes in question, and it was quite evident that a coarse-grained structure gave short life, that a fine grain, if obtained by hard drawing, gave short life, but that the fine grain of hard drawing, relieved of strain by light annealing, gave evidence of the longest life that could be expected from a particular alloy.

This belief is strengthened by the fact that, with the exception of tube failures from mechanical defects, all failures of coarse-grained tubes come within the second tube-trouble classification of "pitted tubes," while all fine-grained soft-tube failures are, with the same exception as noted, from complete dezincification, tube life in this case being the longest that can be expected under existing conditions of operation.

Investigation showed conclusively that the method of tube production then practiced resulted in very great lack of uniformity, which in all probability accounts for the erratic results noted in service. This is forcibly shown by a plate accompanying the original paper containing ten microphotographs of tube sections taken at random from mill shipments. Five of these were with the ordinary mill treatment, and five where the mill treatment had been such as to secure a uniform product. Our Figs. 1 to 4 are selections from this group of tests, 1 and 2 showing the coarse-grained structure of the ordinary mill process, and 3 and 4 the same material after its structure had been reduced by hard drawing and annealing. The chemical composition of all four tubes is precisely the same (70 Cu 29 Zn 1 Sn), and the life of those which have been treated so that their structure is like that shown in Figs. 3 and 4 is considerably greater than that of the tubes with the coarser structure. The reproductions herewith show a magnification of about 50 diameters.

For salt-water conditions such as prevail about New York, the maximum life of the above mixture (so called Admiralty) is approximately six years. No other copper-zinc alloy has as yet given promise of longer life, although sample tubes of 70-30, 80-20, 90-10 are in service and under observation on the theory that zinc, acting simply as a deoxidizing agent, might best be reduced to minimum quantity on account of its electrochemical activities.

If this theory is correct, it will at once be asked, Why any zinc at all; why not pure copper? The answer is that commercially copper is not pure, but an alloy or solid solution of copper oxide in copper, the oxide being electro-negative.

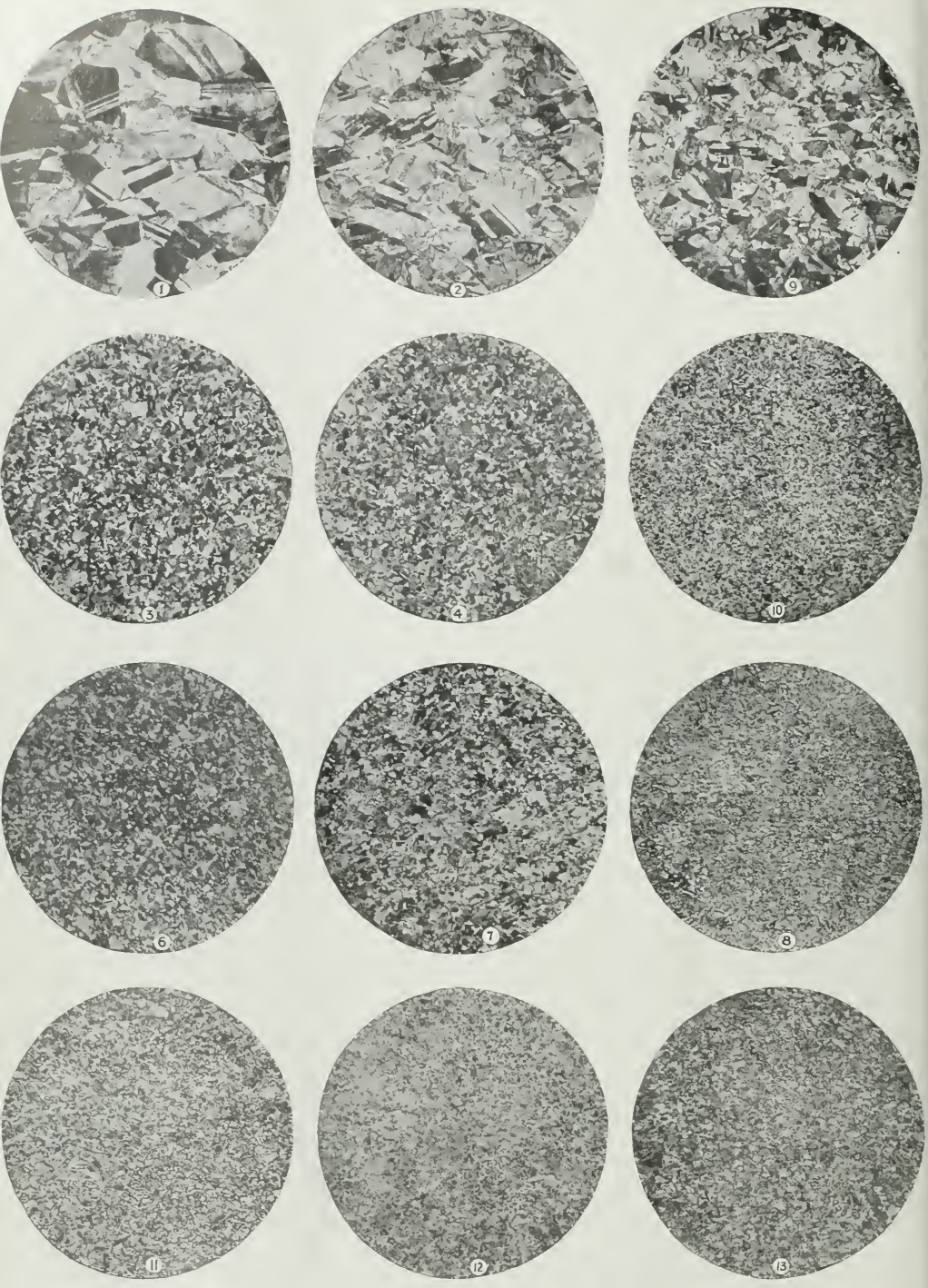
Other alloys than 70-29-1 have been used with varying results; 60-40 or Muntz metal is a standard mixture and has no advantage over the richest copper alloy other than price; 70-30 brass gives similar service to Admiralty and, like this mixture, depends on structure and hardness for long life.

Alloys other than copper-zinc, as Monel metal, 69 Ni 28 Cu 3 misc.; cupro nickel, 28 Ni 72 Cu; aluminum bronze in 8, 5 and 3 per cent. of aluminum have been tried with varying results.

Monel metal is not proof against corrosion in salt water, as is shown by Fig. 5, where the first or left-hand sample shows the result of simple immersion of a Monel metal tube in seawater for a period of 11 months. The central sample shows what happened to the same tube in condenser service for one year and eight months.

The copper-aluminum alloys give promise for salt-water service of being the most durable tube yet produced. Unfortunately they are difficult to manufacture with the higher Al contents. It may be possible that Al acting as a deoxidizer may be fully as effective in the 3 to 5 per cent. mixtures. These are now being tried.

A sample lot of these tubes with an 8 Al, 92 Cu alloy has been in service for 4½ years and shows no signs of deterioration. The right-hand sample in Fig. 5 shows the appearance of one of these tubes after this term of



Microphotographs of Condenser-Tube Materials

service. A second lot of the same mixture failed in four months under the same service conditions, and a third lot now in service gives promise of duplicating the performance of the first.

The reason for the difference in performance evidently lies in the difference in structure as affected by mill treatment. The first lot shows the characteristic structure of the Al bronzes when given a moderate annealing; see Fig. 6. The second lot shows the grain size resulting from heavy annealing, Fig. 7. The third lot shows the effect of light annealing after hard drawing, Fig. 8.

The resulting hardness of the tubes and their ability to resist crushing is practically the same in the first and third lots, Figs. 6 and 8. The second lot, Fig. 7, is softer, with rough longitudinal scratches caused by the scoring of the dies by the oxide of alumina formed by the high temperature of the annealing process.

Figs. 9 and 10 show the structures of 5 and 3 per cent. aluminum-bronze tubes lightly annealed. Structures of 70-30, 80-20 and 90-10 Cu Zn alloys are shown by Figs. 11, 12 and 13 for comparison.

While it is still impossible to draw definite conclusions from the results of the many experiments and investigations under way, it seems reasonable to conclude that

Fig. 5. Monel Metal and Aluminum Alloys

the user may protect himself to the full extent of present knowledge by requiring a manufacturer to furnish:

First—Mechanically perfect tubes, free from slivers and blisters.

Second—Tubes of uniform hardness, as shown from random selection. Test to be deflection between 1-in. square blocks, weighted to secure deflection of 0.005 in. For the 70-29-1 mixture this weighting should be from 400 to 500 lb. for a 1-in. O.D. tube 18 gage.

Third—Uniform grain size in cross-section. This grain size should be fine and secured by final light annealing at low temperature (400 deg. C.) and extended time.

Highly finished tubes are not necessary and indicate

Fig. 14. Dezincified Tube 70 Cu 29 Zn 1 Sn

final hard drawing, producing an nnuniform structure.

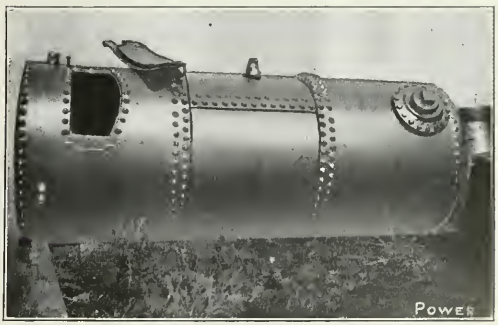
Fig. 14 is a magnified cross-section of a tube having the composition 70 Cu 29 Zn 1 Sn. Dezincification is almost complete; the black areas are spongy copper.

Peculiar Boiler Design

By George B. Longstreet

While looking over some second-hand boilers recently, I came across the one shown in the illustration.

It is a vertical, fire-tube boiler, 8 ft. 1 in. long by 36



Boiler of Peculiar Design

in. in diameter. The shell and firebox sheet are 3/8 in. thick and the tube sheet 7/16 in. thick. The stay-bolts are 7/8 in. in diameter and sustain 42 sq.in. of surface. There are 65 two-inch tubes, 6 ft. long.

The most uncommon features are the double-riveted girth seams and the tube-sheet bracing, thirteen 7/8-in. stay-rods parallel with the tubes, and headed over.

ELECTRICAL DEPARTMENT

The Induction Motor—I

By F. A. Annett

The almost universal use of electric drive has created a demand for motors to satisfy innumerable conditions. However, to build a motor possessing all the desirable characteristics of the ideal motor is something that the electrical manufacturers recognize as physically impossible, and since the limitations of design make it impossible to construct a universal motor, they are giving more and more attention to the specific requirements of each class of service.

For driving certain kinds of machinery the direct-current motor has no equal, the introduction of the interpole having made it possible to meet still more exacting conditions, where variation in speed and constant torque are required. For this reason almost all direct-driven machine tools and many other devices are driven by direct-current motors either of the shunt or compound types.

There are many localities, however, where only alternating current is available, and unless converted into direct current, which requires more or less complicated and expensive machinery, the use of alternating-current motors is necessary; these are usually of the polyphase or single-phase induction type, polyphase induction motors being used almost exclusively for the larger sizes where polyphase current is available.

For a great many working conditions polyphase induction motors, both of the squirrel-cage and wound-rotor types, possess advantages over direct-current motors; for example, in cement mills, grain elevators, flour mills, saw mills, or any place where it is very dirty and dusty and where a fairly constant speed and good starting torque is required. Also their extreme simplicity, low maintenance charges, solidity of construction and ability to stand hard usage are some of the characteristics that make them an ideal type for use on alternating-current circuits. There are cases of squirrel-cage polyphase induction motors driving pumps in excavations that have been entirely submerged and kept on running until pumped dry without any apparent injury to the motor. Some polyphase squirrel-cage rotor-type induction motors are built impregnated with a special oil and waterproof insulation which results in a winding that can be immersed in water and operated there without damage.

There are, however, localities where it becomes necessary for the central station to supply single-phase current to its patrons. Under such conditions, the single-phase induction motor must be used, also in the smaller sizes it has advantages over the polyphase types; it requires but two wires and one transformer, thus reducing the expense of wiring and transformers about 25 to 30 per cent.

The ever-increasing extension of alternating-current systems has created a demand for motors that will meet the requirements of the many industrial conditions, to meet which the electrical manufacturers have made many improvements in alternating-current motors and are now able to supply them for almost any drive, the operating characteristics comparing favorably with the direct-current motor. The changeable-pole polyphase induction motor and the single-phase commutator-type variable-speed motor both operate through wide ranges of speed depending upon the design, and the compensated single-phase motor operates at approximately unity power factor from half to full load.

If the direction of the current is reversed through a direct-current motor the direction of rotation remains unchanged; hence, theoretically any direct-current motor should operate on an alternating-current circuit. Under this condition not only the armature core, but also the field frame must be laminated to keep the eddy currents down to a minimum. For the motor to operate satisfactorily, however, the current must reverse in the armature and in the field at the same time; that is, the field current must be in phase with the armature current. The simplest way to fulfill this condition is to connect the armature and field circuit in series. The speed, torque and load characteristics of this series commutator type alternating-current motor are distinctly analogous to that of its direct-current prototype operating through wide ranges of speed and torque. On account of having no inherent speed regulation its use is confined either to fixed loads such as fans or blowers, or to varying loads where the motor's controller is constantly under the guidance of an operator. For cranes and railway work this type is admirably adapted. The construction and operation of this type of motor were treated in an article in the Oct. 1, 1913, issue of Power.

A shunt motor will not operate satisfactorily on an alternating-current circuit because the field current lags nearly 90 per cent. behind the armature current. This causes the motor to take a very heavy current from the line, develop a very small torque and spark badly at the brushes. To overcome this difficulty a condenser of such capacity as will bring the field current in step with the armature current may be connected in the field circuit (this has the disadvantage of requiring an almost constant frequency), or the field may be connected to one phase of a two-phase circuit, and the armature to the other phase. This brings the armature current almost in step with the magnetic flux of the field, but this loads the two phases unequally. To overcome this two motors may be used combined in the one structure, the first motor receiving its armature current from the first phase and its field current from the second phase, the second motor receiving its armature current from the second phase and its field current from the first. Such motors have been built and used, but have never met with favor, due to excessive cost in construction, low efficiency, sparking at the brushes, and requiring two-phase circuits. Where polyphase alternating current is available it is in most cases advantageous to use polyphase induction motors.

Polyphase induction motors are usually made to operate on two-phase or three-phase circuits, although they are sometimes operated on single-phase circuits; the last mentioned type will be considered later.

The polyphase motor always consists of two parts, the primary member and the secondary member. The primary member is usually stationary, and consists of a laminated iron ring slotted on its inner surface, in which are placed the primary coils, or as it is usually called, the stator winding. Fig. 1 shows the stationary member of such a motor.

The secondary member, or rotor, consists of a laminated iron core slotted on the surface. These slots are usually partly closed at the top and carry heavy insulated copper bars, each end connected to a heavy copper ring. Fig. 2 shows the rotor used in the stator shown in Fig. 1. The copper bars are represented at *A* and the short-circuiting ring at *B*.

If the field frame of a direct-current machine should be arranged so that it could be revolved in a set of bearings, the field coils excited, and the commutator on the armature short-circuited with a copper ring, revolving the field frame would revolve the magnetic field about the armature conductors and would have the same effect as revolving the armature conductors across the magnetic field of the pole pieces; that is, the armature conductors will have an electromotive force induced in them, and since they are short-circuited on the commutator, heavy currents will be set up in them. These currents will react upon the field flux and the armature will revolve with the field frame. This is how the rotor of a polyphase induction motor is made to revolve, only the revolving magnetic field is produced electrically and not mechanically as described above; this will be made evident in the following explanation:

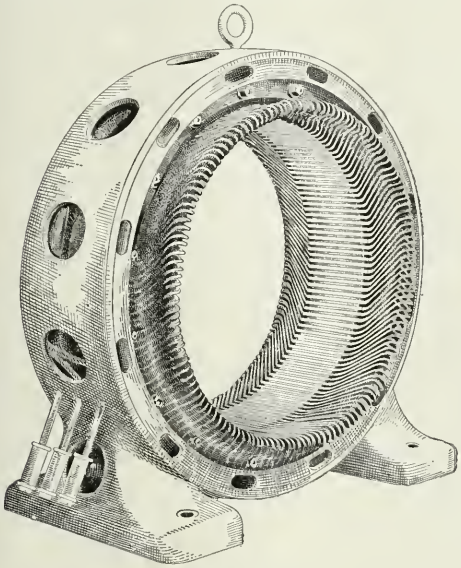


Fig. 1. Typical Stator

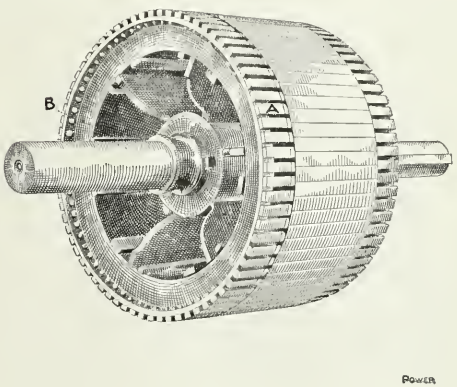


Fig. 2. Typical Rotor

The Two Principal Parts of a Polyphase Induction Motor

When an electric current passes through a conductor it sets up a magnetic field which surrounds the wire. The direction of the lines of force bears a definite relation to the direction of the current, that is, when looking along the conductor in the direction the current is flowing the direction of the lines of force will be clockwise. Fig. 3a shows the direction of the lines of force about a conductor when the current is flowing away from the reader and Fig. 3b the direction when the current is toward the reader.

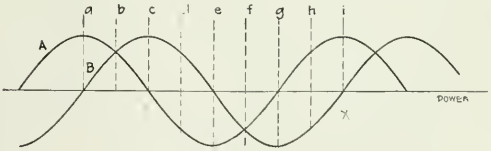


Fig. 5. Represents Current Waves in Two-Phase Circuit

Fig. 3a

Fig. 3b

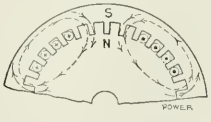


Fig. 4

The action of the magnetic flux about a group of coils in the stator of an induction motor is shown in Fig. 4. The small circles represent the conductors in section. The conductors marked with a cross represent current flowing away from the reader and those marked with a dot, the current flowing toward the reader. The action of the current in each group of conductors is to produce a magnetic field along the dotted lines as shown by the arrow-heads. From this it is seen that the lines of force

surrounding each conductor coalesce into one field surrounding the entire group and produce north and south poles, as shown.

In Fig. 5, the curves *A* and *B* represent the two current waves in a two-phase circuit. That part above the line represents current in one direction and that below the line current in the opposite direction. When curve *A* is at a maximum, curve *B* is at zero, and *vice-versa;* that is, the two currents are 90 degrees apart, and if two sets of windings are properly spaced in the stator of an induction motor and connected to a two-phase circuit a revolving field can be produced as the following discussion will show.

Fig. 6 shows the distribution of a six-pole two-phase stator winding, the outside groups of coils belong to

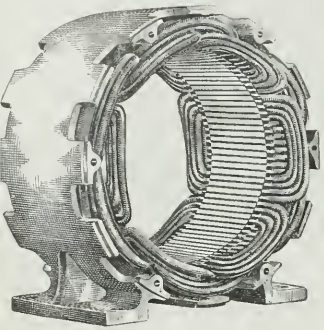


Fig. 6.

place at A_2 and A_3, respectively. Referring to the current curves, Fig. 5, and considering the instantaneous values at *a* it will be seen that the current in phase A is at a maximum, and the current in phase B is at zero. This will give a condition as is shown in Fig. 7a; the current in conductors *A* will be at a maximum and that in conductors *B* will be at zero. Assuming that the current is flowing down through the plane of the paper at *A* and up at A_1, down at A_2, and up at A_3, the conductors with current flowing down are marked with a cross, and those with current flowing up are marked with a dot. Conductors *B*, B_1, B_2 and B_3 are left blank because there is no current flowing in them at this instant. By referring to Fig. 4, and noting the direction of the lines of force set up about the conductors it will

Fig. 7a

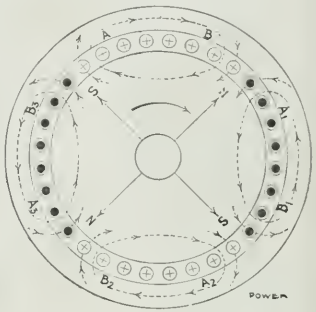


Fig. 7b

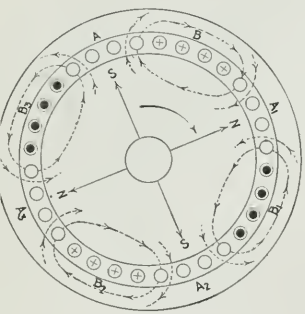


Fig. 7c

Fig. 7d

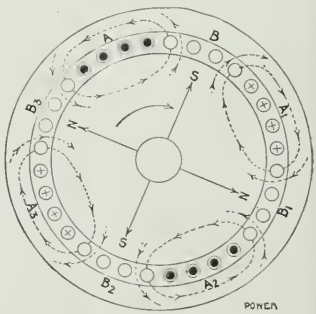


Fig. 7e

Graphic Representation of Rotating Field

ne phase and the inside groups belong to the other hase; there are six groups in each phase, or one group or each pole. This winding is similar to the winding hown in Fig. 1, only the coils are placed differently in he slots.

Fig. 7a represents a simple two-phase four-pole winding laid against the inner surface of a ring. *A* and *B* eing the groups of conductors of each phase, respectively. and A_1 represent the two sides of one group, A_2 and A_3 epresent the two sides of the other group in phase A. 3 and B_1 represent the two sides of one group and B_2 nd B_3 the two sides of the other group in phase B.

If a current is flowing down through the conductors t *A* it will be flowing up at A_1, similar action taking be seen that conductors *A*, A_1, A_2 and A_3 will have lines of force set up about them in the direction shown by the dotted lines forming four equally spaced poles, north poles at *B* and B_2, and south poles at B_1 and B_3, as indicated.

At the instant *b* on the curves *A* and *B*, Fig. 5, the currents in the two phases have the same value and direction. In Fig. 7b, assuming the current to be flowing down through the plane of the paper in *B* and B_2, and up at B_1 and B_3, then the currents in *B*, B_1, B_2 and B_3 will be in the same direction as the currents in *A*, A_1, A_2 and A_3, respectively, and the lines of force will encircle the groups *A* and *B*, A_1 and B_1, A_2 and B_2, and A_3 and B_3, respectively, in the direction indicated. This

will cause the poles to shift one-sixteenth of a revolution in a clockwise direction as indicated by the arrows.

The current in phase A at the instant *c*, Fig. 5, is at zero, and the current in phase B is at a maximum value. This will produce a condition as shown in Fig. 7c, and the four poles will have shifted around one-sixteenth of a revolution in the same direction as before.

At the instant *d*, Fig. 5, the currents in phases A and B are again equal, but that in phase A is opposite in direction. This is just as it should be, as will be seen in Fig. 7d. The current in phase A will flow down through the plane of the paper at A_1 and A_3, and up through the plane of the paper at A and A_2. Lines of force will be set up around the groups of conductors $B\ A_1$, $B_1\ A_2$, $B_2\ A_3$, $B_3\ A_4$, respectively, and the four poles will have shifted around one-sixteenth of a revolution in the same direction as before. The position of the poles is as indicated.

The current in phase A at the instant *e*, Fig. 5, is again at a maximum and that in phase B is at zero. The corresponding positions of the poles are represented in Fig. 7e.

During the period from *a* to *e* the current in each phase has passed through one alternation, or one-half cycle, and the poles have shifted 90 degrees, or one-fourth of a revolution, that is, one pole space. In a six-pole machine the poles would have shifted one-sixth of a revolution; in an eight-pole machine one-eighth of a revolution, etc. From this it will be seen that as the currents in the two phases continue to change, the magnetism sweeps around (although the core and coils remain stationary) at a speed per minute which is equal to the alternations per minute divided by the number of poles per phase.

Since one cycle equals two alternations, and the frequency is expressed in cycles per second, the formula for the revolutions per minute may be expressed thus:

$$S = \frac{120\,f}{p} \qquad (1)$$

Where

S = revolutions per minute,
f = cycles per second,
p = number of poles per phase.

As the magnetic field revolves about the rotor, the lines of force are cut by the rotor conductors just as the conductor in the armature of the direct-current machine would cut the lines of force if the field magnets were revolved mechanically, and in the same way the rotor conductors will have an electromotive force induced in them, which will set up currents that react upon the magnetic field of the stator, and will be carried around with it.

Referring again to the direct-current machine, if the armature had been revolved at the same rate as the field magnets the conductors on the armature would not have cut any of the lines of force from the field magnets and would not have an electromotive force induced in them. From this it will be seen that the armature must revolve slower than the field magnets, so that currents may be set up in the armature conductors to develop the necessary torque to carry the load. This is also true of the polyphase induction motor. The speed S referred to in formula (1) is the speed at which the magnetic field revolves, or synchronous speed, as it is usually called. The difference between the synchronous speed and the indicated speed of the rotor is called the slip. In a given motor the slip depends upon the load. At no load the motor runs at very nearly synchronous speed, while at full load in well designed motors the slip should not amount to more than 2.5 per cent. on large motors and 7.5 per cent. on small motors.

If S' represents the indicated speed of the rotor and S the synchronous speed as expressed in formula (1), then the slip equals $S - S'$. Expressing this as a percentage:

$$Per\ cent.\ slip = \frac{(S - S')\ 100}{S} \qquad (2)$$

For example:

A six-pole motor is connected to a 60-cycle circuit, the indicated speed is 1150 revolutions per minute. Find the percentage of slip.

$$S = \frac{120\,f}{p} = \frac{120 \times 60}{6} = 1200\ r.p.m.$$

$$Per\ cent.\ slip = \frac{(S - S')\ 100}{S} = \frac{(1200 - 1150) \times 100}{1200}$$

$$= 4.17\ per\ cent.$$

Two Cases of Hunting

The letters by A. N. Kerr and V. K. Stanley on the above subject which appeared in POWER for Sept. 2, are noted. Theirs are evidently cases of the engine governors being oversensitive. In such cases the engines when on load alone will run steadily and keep a constant voltage, but when run in parallel the trouble starts, which usually ends up by one set falling out of step.

The writer has had several cases of this kind and in every instance has been able to overcome it by fitting a fairly powerful oil dashpot to the governors with adjusting screws to regulate the flow of oil from top to bottom of the piston. Such an arrangement is easily fitted, even in the case of the flywheel type of automatic governor, in which case it would be carried off a knuckle joint at its bottom end and fitted with a gland where the connecting-rod leaves the cover. An arrangement similar to this was fitted to some large sets made by the Westinghouse Machine Co. about twelve years ago and put into a London station where they did well.

E. R. PEARCE.

Rochdale, England.

A Giant Merger of Power Systems, four in all, which will furnish power for the operation of industries in western Nevada, the eastern part of California and a large area of southern California, has just been announced by Delos Chappell, president of the Southern Sierras Power Co. The territory to be covered by this system extends from a point as far north and east as Round Mountain in Nevada, to Riverside and surrounding towns.

The various systems will be connected through a line between Bishop and Lundy Lake and the full connection will be effected by the construction of a line from Bishop to Long Valley by the Silver Lake Power & Irrigation Co., and by an extension of the Pacific Power Co.'s lines from Long Valley to Lundy Lake.

The Silver Lake Power Co. has projects on the Owens River, while the Pacific Co., has its plant on Lundy Lake. The parent company is the Nevada-California Power Co., that gets its power from a chain of five hydro-electric power plants on Bishop Creek, which is also the source of the supply of the Southern Sierras Power Co. The latter company also has extensive steam plants at San Bernardino, Calif.

GAS POWER DEPARTMENT

The Farnham Bituminous Producer

Of more than passing interest in the field of suction-as producers is that developed under the Farnham pat-nts in England and installed in an electric-lighting lant at Skelmorlie, a residential district on the Clyde in Scotland. Although having now been in operation for ver two years its construction is perhaps unfamiliar to ost American readers.

The producer, as shown in Fig. 1, is of the up-draft ype and the working principle eliminates the chance of arry matter reaching the engines. It consists of a bot-om furnace *A*, above which, within the same casting, is brick-lined generator *B*. At the top of the generator he gas is taken out and is conducted downward on its ay to the engine through a pipe surrounded by a water acket consisting of annular rings, whereby steam is pro-ided to mix with the air necessary for gas production, he air inlet being at the top. The annular jacket *D* urrounds the furnace part of the producer and thus rovides a means of rapid steam raising.

A novel feature is the rising and falling grate over hich the bituminous fuel is charged and a horizontal liding plate *E* actuated by gearing, which can be in-erted at the bottom of the body of incandescent fuel for upporting it while the furnace is being recharged. Rais-

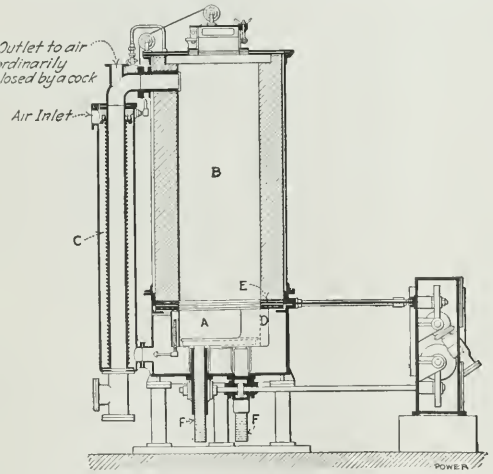


FIG. 1. SECTION THROUGH FARNHAM PRODUCER

ng and lowering of the grate is effected by the racks *F* nd pinions inclosed in such a way as to be out of con-act with the ashes or clinker in every position of the grate. Fig. 2 shows the grate in plan and the position f the four elevating-rack rods. The racks and the worms by which the plate is made to travel are either actuated by hand or by an electric motor and speed-reducing gear, he essential parts of which run in an inclosed oil bath.

To charge the producer, the furnace grate with its weight of incandescent fuel is raised about 10 in. The gear-driven sliding-plate is then introduced between the top of the grate and the bottom of the fuel bed. The whole body of fuel is thus supported while the grate is lowered to its normal position and the fresh charge is

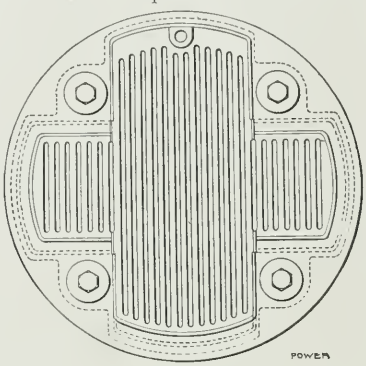


FIG. 2. GRATE OF FARNHAM PRODUCER

inserted. The supporting plate is then withdrawn and the incandescent fuel rests on the fresh supply. The charge, which generally amounts to about 300 lb. in a producer of 100 b.hp., is fed only at intervals of from three to four hours, according to demands upon the producer and the process of charging takes from three to four minutes.

As soon as the incandescent fuel falls on the fresh charge the volatile matter is liberated and passing up through the whole depth of superimposed fuel, is decomposed into fixed gases, thus eliminating tar. Moreover, opening the door for charging does not in any way affect the working of the producer or the quality of the gas.

Poking the fuel bed is said to be unnecessary, as the action of raising and lowering the grate compresses the fuel column in such a way that cavities or rifts in the fuel are eliminated. In the opinion of Dugald Clerk, the plant is capable of producing quite clean gas from any bituminous fuel whether of the caking or noncaking variety, as the fuel which he tested was highly bituminous and caking. The consumption of water for all purposes under ordinary conditions of working is comparatively small. For cooling the gas it amounts to 1.17 gal. per hp.-hr., while for the vaporizer only 0.3 gal. per hp.-hr. is required.

The external boiler comes into operation as soon as the gases leaving the producer are hot enough to vaporize the water trickling over and through the perforated ledges surrounding the gas main, the necessary temperature being reached about 1½ hr. after starting. For immediate steam raising after starting, the annular jacket, fitted at the bottom of the producer in contact with the hottest part, comes into operation.

Performance of Motor Ship "Monte Penedo"

After covering over 30,000 miles in regular service between Hamburg, South American ports, and New York, the motor ship "Moute Penedo" was recently inspected at her pier in Brooklyn and the Diesel engines were found to be in excellent condition.

This vessel, it will be remembered, is a cargo boat of 4000 tons gross register and was placed in commission about a year ago. She is equipped with two four-cylinder, two-stroke-cycle Sulzer-Diesel engines each of 850 hp. at 160 r.p.m. and has a speed of about 11 miles per hour. Quoting from the inspector's report:

"In order to inspect a cylinder head and a piston, one cylinder head was taken off and the piston taken out. The wearing surfaces on the piston, piston rings, and especially the cylinder were in perfect condition and the latter was as smooth as a mirror. The parts of the cylinder cover and piston forming the combustion space appeared black, as if covered with a thin coat of paint, but no large carbon deposits were found. Neither was there any appreciable amount in the exhaust ports.

"No troubles were experienced on any of the main bearings, pins or crosshead guides. The parts requiring the most attention were the valves for the cooling water, bilge pumps and air compressor. The fuel-pump packing seems to be tight and no leakage has been apparent."

Pure mineral oil is used for lubricating the cylinders, the consumption averaging about 6⅓ gal. per 24 hr. The lubrication of other parts (including all the auxiliary engines) amounted to about 46 gal. per 24 hr. Sea water is used for the cylinder jackets, piston and oil cooling. The fuel used is a gas oil having a specific gravity of 0.86 to 0.89 and the consumption averaged 15,604 lb., or approximately 2170 gal. per 24 hr.

Horsepower of Small Gas Engines

The method of computing the indicated horsepower of a gas engine running at slow or moderate speed follows so closely the procedure for steam-engine practice that seldom any misunderstanding arises. The principal point to bear in mind is that in the $\frac{"PLAN"}{33{,}000}$ formula N must represent the number of explosions which in a hit-or-miss governed engine may not bear any definite relation to the revolutions per minute. Moreover, in a gas engine a stiffer spring must be used, owing to the high explosion pressures.

With small high-speed engines running at 800 to 1000 r.p.m. the problem is quite different. Here the speed is too high to obtain accurate results with an ordinary indicator; hence, it is usual to estimate the mean effective pressure. The latter, however, will vary with the load and is dependent upon several factors, including the mixture, the compression pressure, and the time of ignition. Therefore, when running underloaded it is practically impossible to arrive at the horsepower, without actually measuring the brake horsepower. The full-load horsepower may be estimated, with fairly close approximation, however, if the cylinder dimensions and speed are known, by assuming a mean effective pressure for full-load conditions. With tight valves and pistons a mean effective pressure of 80 lb. may be taken for gasoline, 75 lb. for natural or illuminating gas and 65 lb. for producer gas; then substitute this value for P in the formula.

$$Horsepower\ (per\ cylinder)^* = \frac{P\,L\,A\,N}{33{,}000 \times 12}$$

Where

P = Mean effective pressure;
L = Length of stroke in inches;
A = Area of piston in square inches;
N = Explosions per minute.

This may be written:

$$Horsepower\ per\ cylinder = \frac{P\,L\,0.7854\,D^2\,N}{33{,}000 \times 12}$$

where D = *diameter of cylinder*

Substituting for gasoline:

$$I.hp. = \frac{80\,L\,0.7854\,D^2\,N}{33{,}000 \times 12} = \frac{D^2\,L\,N}{6300}$$

Assuming a mechanical efficiency of 85 per cent.

$$B.hp. = \frac{D^2\,L\,N}{6300} \times 0.85 = \frac{D^2\,L\,N}{7400}$$

This formula may be expressed in other terms to suit special conditions. For instance, in a four-stroke-cycle engine with jump-spark ignition where an explosion occurs at every second revolution, N may be taken as the revolutions per minute and the formula will become

$$B.hp.\ (per\ cylinder) = \frac{D^2\,L\,N}{14{,}800}$$

This is the more familiar form, but it has been further simplified by the American Licensed Automobile Manufacturers Association in assuming a piston speed of 1000 ft. per min., which is equivalent to a 6-in. stroke and 1000 r.p.m. or, 5-in. stroke and 1200 r.p.m. Using the round number 15,000 for the denominator this reduces to:

$$B.hp.\ (per\ cylinder) = \frac{D^2 \times 6 \times 1000}{15{,}000} = \frac{D^2}{2\frac{1}{2}}$$

This is the formula by which automobile engines are rated.

Alcohol as a Decarbonizer

In a paper read at the recent Gas Engine Show, at Kansas City, J. A. Anglada cited some interesting experiments which he had made with denatured alcohol as a carbon-remover in gasoline engines. He found that the best results were obtained when the combustion space of a hot engine is entirely filled with denatured alcohol and allowed to stand for six or eight hours. Although heat is not absolutely necessary, it hastens the loosening of the carbon deposit which will pass out through the exhaust when the engine is started.

In cases where some of the alcohol leaked past the piston into the crank case it rendered the lubricating oil unfit for use, although when run in this way for a very short period the presence of alcohol in the oil appeared to cleanse the bearing surfaces.

After the carbon has been removed in this way a small amount of denatured alcohol (from 2 to 4 oz.) introduced into the combustion space every three or four days, when the engine is in constant use, will keep the cylinders free.

*Strictly speaking, this should be "per cylinder per end," but as the present discussion deals only with small engines, which are always built single-acting, the formula may be understood to give the horsepower per cylinder.

REFRIGERATION DEPARTMENT

Indicating the Compressor

By Peter Neff

Frequently the question is asked, "Do you advocate the indicating of ammonia compressors? The reply is, Certainly, if it is done right and for some specific purpose. When, however, an engineer mails in a card and asks to have some information regarding his compressor deduced

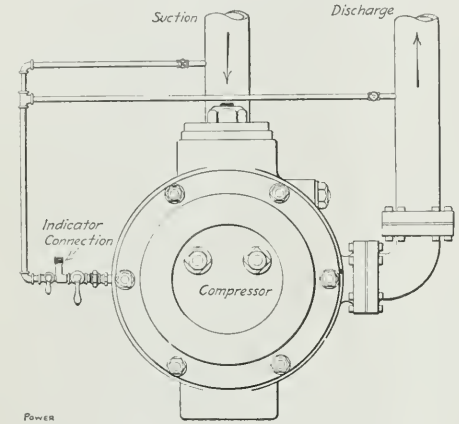


Fig. 1. Indicator Cock Connected to Suction and Discharge Lines

from it, my belief is that any deductions made will be far from being of any value, unless one is perfectly familiar with the engineer who took the diagram, his instrument and methods.

The indicator in the hands of one who has made it a study, and who is proficient in its manipulation is a most useful instrument, but when not so used it may be an erroneous guide, or, to say the least, a slow one.

Usually it is better to trust to an examination of the compressor by a good man, than to what is ordinarily expected to be shown by the indicator. The rythmic noises in an engine room are to the true engineer what an orchestra is to the musician, and he is just as quick to detect when a piece is out of harmony.

The outsider who comes in to inspect a compressor can make more headway by a careful examination than he can by indicating. One must bear in mind that the uses of the indicator for steam engines are not in most cases analogous to those for compressors.

Our best engineers when overhauling their compressor become perfectly familiar with its construction, and the functions which each part performs, and can tell how these should be to obtain maximum results. The piston should be so marked after being adjusted that any movement will be readily noted. No indicator is required for this. A broken valve or spring will manifest itself in many ways to an engineer. And so through the list of most of the troubles to which compressors are liable.

An engineer should have an indicator for his compressor and should know how to use it. It can do much to help him. The point I want to make here is, that many of the things which writers on compressor diagrams show as being determined by the indicator, are as plain as can be to a good engineer without its use.

Some may say that I do not think much of the indicator; far from it, years of study of indicator diagrams from compressors has made me realize, however, that we have in it an instrument with frailties of its own, and much affected by those of man.

In a certain case an engineer spent considerable time in indicating a double-acting compressor, and after much figuring from diagrams taken, made a lengthy report which was in substance that there was too much clearance. It took about one hour to take the head off and determine that there was about $\frac{3}{8}$-in. clearance. He was right, although he did not know the amount, but what a labor to find it out in that way.

For many years there have been published from time to time interesting articles on indicator diagrams, and

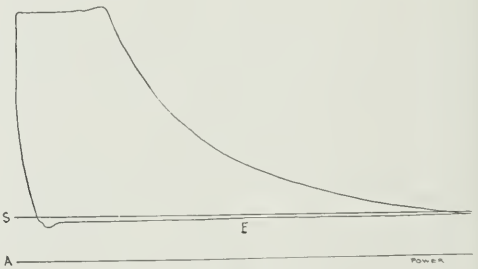


Fig. 2. The Usual Diagram

where these have gone into some great problem connected with compressors, they have been of interest and value. But most of them have merely shown diagrams illustrating various difficulties which could have been known from an examination or other ways more readily.

There have been some published works on the indicator which are splendid and engineers should have them in their possession. The tables and labor-saving devices which they show are helpful, especially in plotting those two useful curves, the adiabatic and the isothermal, which truly are essential to the interpretation of a card.

In compressors, if there is any one thing that we are particularly interested in, it is that all the vapor possible be handled at each stroke. One of the things contributing to this is the filling of the compressor cylinder as nearly as possible to the pressure existing in the suction line. The more nearly this is accomplished the less will be the horsepower and the greater the production of refrigeration. When a 100-lb. spring is employed to

draw the diagram, should the suction pressure be as low as 10 lb., there will be but $\frac{1}{10}$ in. on the diagram in which to study the suction condition. Now to attempt to scale this, especially if a pencil has been used to trace the lines, leaving a comparatively wide mark, is fraught with many difficulties even with the use of a magnifying glass.

Very early it was learned to take diagrams for studying suction conditions by the use of a low-tension spring, a 16-lb. spring being a good one for this purpose. Many of the modern indicators are so constructed that these low-tension springs can be used without damage to the instrument. When not so constructed it is usually not a difficult matter to arrange to block the piston so as to prevent any damage arising. With a 16-lb. spring the 10-lb. suction pressure will be quite an appreciable distance on the diagram.

While engine-room gages are all right for general indications, they are by no means accurate. Where there is a mercury-column gage and it has been corrected by the use of a barometer, the pressure can be accurately determined. Unfortunately for most engineers, the engine-room equipment does not contain a mercurial gage, so that usually the readings are taken by ordinary gages. The diagram is scaled to see how it coincides, and in spite of stiff suction-valve springs and small ports it usually comes out that the compressor is filling to suction pressure. Very little attention has been paid to this point, yet there is opportunity for considerable loss, and the indicator can be used to advantage.

In 1907-8, having occasion to make a study of the suction condition in compressors, the author devised a meth-

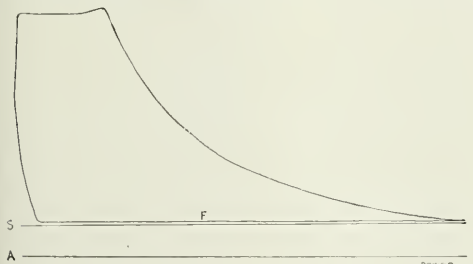


Fig. 3. Pressure in Cylinder Apparently Higher Than in Suction Line

od for overcoming this difficulty. If the indicator could in some way be made to record the pressure existing in the suction at the time the diagram is taken, it would manifestly be a guide to go by, which would make unnecessary the scaling of the diagram and the consequent liability to error, as well as doing away with the uncertainty of the engine-room gage reading. In short, the diagram would show to the eye the relative condition of filling pressure to suction pressure.

This condition was accomplished by making a connection from the suction line near the compressor to the indicator, so that when the indicator was shut off from the atmosphere and the compressor, it could be opened to the suction-pressure line. The controlling valve for this should be close to the indicator, as shown in Fig. 1.

It may be urged that as the diagram and the suction-pressure line are not drawn at one and the same instant they are therefore not comparable. A little experience by drawing the suction-pressure line both before and after taking the diagram will show that conditions do not change so rapidly as to materially affect the value of this process. While this method did what was expected of it, it brought out some other interesting facts.

The ordinary diagram obtained would be similar to Fig. 2, in which A is the atmospheric line, S the suction-pressure line, and F the filling line of the diagram. Now the portion of the diagram lying between F and S represents a measurable loss in compressor efficiency, and may be caused by too stiff springs on the suction valves or too small ports for admission of the gas. If the ports are too small the speeding up of the compressor will increase the swing of the line F below S. If the ports are large enough but trouble is with the valve weight or spring, the speeding will not affect it materially.

While indicating compressors where there was practically no drop in pressure for the opening of the valve, I was surprised at times to get a card similar to Fig. 3. Here it will be noticed that the line F is above the line S, in other words, the indicator says that the pressure to which the compressor filled was higher than that existing in the suction line. This may be accounted for as follows:

The tracing of the diagram is in the direction of the arrows, Fig. 4. Now suppose that there is some lost motion in the indicator-pencil connections. The atmospheric line is drawn when the lost motion is all taken up by gravity. As the compression curve is traced the spring is pushing the pencil upward. When the discharge takes place and the pressure begins to decline in the compressor, owing to the friction of the pencil, it is held up while the spring takes up the lost motion, so that the pencil is higher than it should be by the amount of the lost motion. When the suction-pressure line is drawn, the pencil, in the meantime being removed from the paper, falls through the lost motion, and when the suction pressure is applied it is raised by the spring. Both the lines A and S are taken with the lost motion out while F has it.

This led to an examination of indicators and it was found that very few indicators were accurate, and that great care was required in keeping an indicator in fit condition. A slight binding of the indicator plunger will produce the same trouble.

If an indicator had this defect, and a high-tension spring was used for tracing the diagram, and the suction

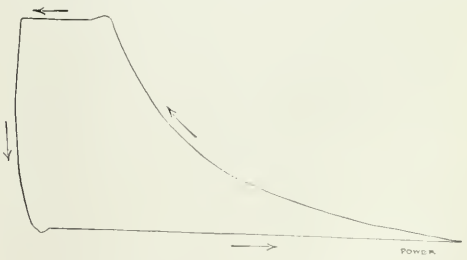


Fig. 4. Accounting for Trouble in Fig. 3

condition determined by scaling the card, manifestly the compressor would be filling to a less amount than shown.

Where there is a considerable drop in the pressure in the compressor before the suction valve will open, this er-

ror will manifest itself in not making the drop as great as it should be, but from that point on the line F will be comparable to A and S.

The fact that this trouble tends to show that the compressor is filling better than it is and further fact that suction pressures are apt to be taken from ordinary gages, has no doubt been a fruitful source of making compressors appear better than they really are.

When studying discharge conditions the effect of lost motion is to considerably distort the graphic record of the discharge. When one adds to the trouble noted, the careless way in which indicators are often connected, it is not to be wondered at that one views with suspicion diagrams submitted for examination. Frequently the cord transmitting the motion from the crosshead does not move parallel with the piston of the compressor, and there is always the uncertain amount of friction of the pencil.

There is one difficulty in drawing the suction-pressure line that must be guarded against. Sometimes liquid will drain into the pipe leading from the suction line to the indicator. When this is the case and it strikes the hot cylinder of the indicator, there will be trouble.

Fig. 5 illustrates another interesting feature brought out in this method of indicating. This diagram has been somewhat distorted to make more plain the point to be illustrated. The suction-pressure line has a loop at both

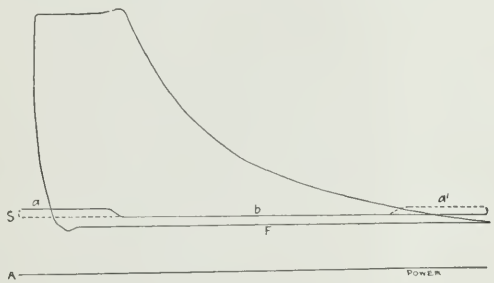


Fig. 5. Loop at Both Ends of Suction-Pressure Line

ends. It must be borne in mind that when tracing either the suction or the discharge-pressure line the conditions existing at both ends of the stroke are shown. In Fig. 5 that portion of the suction pressure corresponding with the diagram is shown as a solid line, while that for the other end for which no diagram is shown is dotted. When the piston is practically at rest at the end of the stroke, the suction pressure indicated by a represents the true suction pressure existing in the suction line. Now as the piston moves forward the line a falls until it reaches b. At the end of the stroke it rises to a'. This clearly indicates that the pipe supplying the compressor is not large enough to permit the proper flow of gas. This method has proved interesting in making a study of port velocities, by having an arrangement whereby the area of the port could be changed, and combining this with different speeds.

Fig. 6 is the reproduction of a diagram where not only the suction-pressure line is shown but the discharge pressure as well. Note the banking up of the pressure in the discharge line, and its relation to the discharge of the gas from the compressor as shown by the diagram. This diagram also indicates how difficult it is to study the suction condition when a high-tension spring is used.

A diagram such as this is difficult to obtain, for the use of the indicator with cold suction gas and hot discharge gas is apt to disarrange the working parts to some extent. It is not recommended to try to show all on one diagram. Take up one thing at a time and study that by a series of diagrams.

Should it be desired to reproduce the cards, which is sometimes desirable, an easy method is to put a piece of carbon paper next the indicator drum and use a trans-

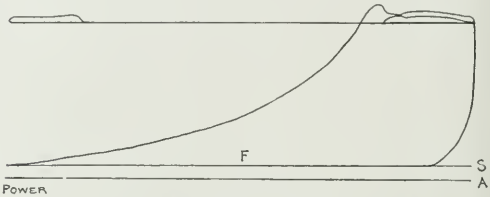


Fig. 6. Diagram Showing Both Suction- and Discharge-Pressure Lines

lucent paper. In this way a dark line may be made on both sides of the paper, enabling a blueprint to be made from it. Care must be exercised as the paper is usually rather thin and a slight excessive pressure on the pencil will cause remarkable distortion sometimes.

My suggestions are to any engineer, to have a good indicator, keep it carefully and do not loan it. Have a good permanent connection for it, including suction and discharge-pressure lines. If possible have a reducing motion permanently connected. If this is not possible, arrange it so that the reducing-motion connections are always the same. Practice the taking of diagrams, for it requires practice to become in any way skilled.

Take up some point for investigation and work it out by a series of diagrams, and these should be plainly marked and dated for future reference. For example, different tension springs can be tried on the suction valves. Or the suction pressure can be taken from different points and the question of the size of the ports and the limit of speed applicable for efficient work determined. Go after the discharge condition. Try to get the compressor to handle a maximum amount of gas with a minimum expenditure of energy.

In doing any of this work many interesting collateral conditions are likely to arise, which can be studied for the benefit of other engineers as well.

*

In its simplest form refrigeration can be found on practically every vessel afloat, and, according to C. J. Beck, in a paper before the Third International Congress, there are not less than 843 vessels fitted with insulated chambers and refrigerating machinery. The majority of these vessels are thus equipped only for the purpose of carrying fresh food supplies for their passengers and crews, but the cooling equipment is usually quite extensive. A vast fleet of steamships is continually employed in carrying the surplus meats of this country, Canada, Argentina and Australia to the densely populated markets of Europe. The value of the refrigerated ocean transportation to the fruit trade, the fish and dairy industry and many others, is obvious.

EDITORIALS

Saving Our Coal

In these days of coal burning when the enormous demands from land and sea are depleting the supply, it is time that some consideration be given to the fuel of the future. In engineering circles of late years there has been some discussion on this subject and some practical attempts have been made to conserve the coal supply. For a number of years Germany has been utilizing its culm and waste banks in gas producers and has been recovering some of the numerous constituents in coal.

Even this country with its wonderful resources has been awaking to the outlook as evidenced by the developments now under way by the Lehigh Navigation Co., at Hauto, Penn., and those of the Peabody interests in Christian County, Ill. In both it is the intention to generate current at the mouth of the mine and within a reasonable radius supply the demands for power and light. With the lower grades of coal the transportation charge is a large item. When the plant is located at the mine this cost is eliminated and is supplanted by that of transmission which is considerably lower, although the two will finally balance when the distance from the central plant becomes excessive.

These developments, however, are only a beginning. To obtain the last item of value, coal must no longer be treated as a fuel and the raw product burned on the grates for its heat value only. It contains a number of byproducts which in themselves are valuable, and with proper methods of distillation may be recovered. Its treatment should be concentrated at the mines so that the transportation of raw coal may be minimized and the energy transmitted in the form of gas or electricity to the markets. To serve all parts of a large country like our own in this way, where the distances from mine to service are necessarily great, would be impractical at present, but the possibilities for the territories adjacent to the mines, are worth considering.

Along the line proposed above some interesting papers were recently presented in England before the British Association for the Advancement of Science and are to be briefly abstracted in the Oct. 21 issue. Professor Burstall proposes the artificial production of oil fuel. Heretofore coal has been gasified with the object of producing the richest and largest quantity of gas. It is quite practical, however, to change the conditions of carbonization so as to obtain a large yield of fuel oils and other compounds of value and at the same time produce a standard illuminating gas, although this would be a secondary consideration.

As will be seen in the abstract the same author outlined a plan of treatment at the pit's mouth. After separation the tar is subjected to fractional distillation to obtain from it the various oils, and the gas unpurified from sulphur is supplied directly to a gas engine for the generation of electricity. The exhaust gases from the engine are treated in conjunction with liquor from the ammonia plant and the nitrogen and sulphur of the raw fuel recovered in the form of ammonium sulphate.

Professor Armstrong went so far as to suggest that the use of raw coal for heating purposes be rendered illegal. All coal would then be subjected to destructive distillation and the maximum quantity of byproducts would be recovered. The methods of burning the gas would also need reform and Professor Bone's flameless combustion might be expected to receive extended application.

While today these refinements seem visionary, all of them might be practically applied. Utilizing our present resources so as to obtain the maximum value from them is true conservation. It would be in the interest of economy to investigate the plans proposed, for the more fuel we are able to save the more there will be for future generations.

Condenser Tubes

Corrosion and pitting of condenser tubes has long been a perplexing problem in power-plant operation. Many theories have been advanced to account for this phenomena only to be shattered through inconsistent behavior of the tubes under like conditions. Notable among these theories was that of stray currents from outside sources and one company even went so far as to attempt to neutralize these by a counter-current generated within the power house. The experiment failed to prove anything, however, and was discontinued.

Another theory to account for certain tubes deteriorating more rapidly than others in the same condenser and subject to the same conditions, is sagging. It was pointed out that when the condenser is out of service water is allowed to remain in the sagging tubes and hastens galvanic action. Undoubtedly this is a contributing factor, but to what extent is unknown.

The latest investigations while pointing to local galvanic action in the presence of an electrolyte, such as river water containing sulphuric acid, as the primary cause, show, nevertheless, that the extent and rapidity of the action depend upon the tube itself. It is not so much the composition as the structure of the tube which is the governing factor, annealed tubes giving the longest life. Moreover, coarse-grained tubes appear more susceptible to pitting and fine-grain tubes to dezincification.

The beneficial effects of annealing as found by the investigations of the committee appointed by the Association of Edison Companies, reported on page 531, recalls the case of a large power company which came to our attention some time ago. After experiencing much trouble with condenser tubes and trying various compositions, a large shipment was ordered from England and gave complete satisfaction. Upon investigation it was found that these tubes had been made in this country and were shipped to an English firm which put them through a special annealing process. Furthermore, they did not cost any more than tubes bought in this country.

What a License Stands For

One unfortunate effect of an engineers' license is its tendency to swell the head of its possessor. While an engineer may justly take pride in the acquiring of a license, particularly in a state where the examinations are severe, he should not lose sight of the purpose of a license. License laws are passed and licenses distributed, not for the sake of honoring the recipients, but to protect the public.

If an engineer is inclined to be unduly exalted by his license let him remember that barkeepers and peddlers have licenses too, and after all any license is a permit as much as an indorsement—it means that the holder is allowed a privilege, although he has attained a right; he is stamped "good enough" and is not necessarily wonderfully better than his fellows. License examinations have to be easy enough to pass the average as well as hard enough to bar out the incompetent.

Of itself the certificate of a state's approval of an engineer's fitness to perform the duties of his profession, has no virtue. There is no magic about it that can confer ability where none existed before. It does not render him immune from the possibility of making a mistake.

To the really ambitious, conscientious engineer the license is only a milestone indicating that he has reached a certain point in his acquirement of proficiency. He realizes that thus far he has only met the entrance requirements of the race and if he wins a place finally he must not only not relax in his efforts to add to his knowledge, but must double them. The van in the field is easily left, but competition in the forefront is keen.

⁂

On the Job

This oft-repeated phrase may mean much or little, depending upon the sense with which it is used and understood. An engineer can be on the job and not accomplish much more than a dog scratching fleas: plenty of action but not getting anywhere.

Day after day and week after week some engineers are on the job. The engines are started each morning on time and are as promptly shut down at night. No accident of a serious nature occurs from year to year and these men are called good engineers.

Look into their plants and the floor and surroundings will be found neat and clean, the engine wiped and the bright parts polished; the engineer is a conscientious man and keeps the plant in the best condition he knows how, but is he *on the job?*

Does he get as much of the heat in the coal into the water in the boiler as is possible? Is the heater raising the feed water to the highest possible temperature, or are the heater tubes covered with grease or partly filled with scale, either of which will prevent efficient work?

The engineer who is *on the job,* not only sees that conditions are right externally, but internally as well, to produce the most economical results. It is not the man who is always in dirty work clothes who is *on the job.* The man who works with his head accomplishes more than he who always has some tool in his hand.

The brains of the successfully operated plant are in the engineer's office, where the schemes for better plant operations are worked out. As a practice, nobody looks to the firemen or oilers for ideas for plant betterment, although both are *on the job* to the extent of their capacity.

More than one chief engineer has failed to make good because he did not have the ability to handle the men in his department. Many owe their success largely to their ability to get their assistants to coöperate with them in the performance of power-plant duties.

If an engineer is *on the job,* he will not only be able to keep the plant running and maintain harmony among the men, but he will be ever on the hunt for losses and for methods of improving the operating conditions.

In one steam plant, operated by a large manufacturing concern, the feed water is pumped from the river through tubes running along the inside of the boiler-furnace setting, these tubes acting as feed-water preheaters. Although the plant has been operated fifteen years, a heater has never been installed because the engines are run condensing and someone decided a heater would be useless.

During these years, however, steam was used in an adjoining building, and a large amount of it has been allowed to escape to the atmosphere. As a result, coal is burned to heat feed water that could have been heated by the escaping steam from the factory building.

Had the engineer been *on the job,* he would have shown the officials of the company that this loss would be prevented by installing a proper feed-water heater.

There are more ways of being *on the job* than always starting up and shutting down promptly and keeping things going meanwhile.

⁂

The blowing of an exposed 50-amp. fuse on a motor in a factory room recently created a panic among the fifty or more girl employees, several of whom were injured. This would have been avoided if nonarcing fuses had been used.

⁂

Continuously running boilers below rating when fewer would carry the load at or above rating reminds us of the boy who baled water from a sinking boat with a leaky tomato can while a ten-quart pail floated at his feet.

⁂

It is only too true that the chief reason the plant owner hesitates to buy needed equipment is because he has been fooled so often that he is afraid to trust or believe anybody.

⁂

Some day engineers will learn that the only language the owner understands is so many pounds of steam or kilowatt-hours per dollar and not per pound or ton of coal. Has that day come for you?

⁂

We have been informed of a new charge against the isolated plant by central-station promoters. It has been christened "brain fag." No, it has nothing to do with the engineer, but concerns only the plant owner or manager. The reason given for the charge is that the worry, the mental anguish, the "brain fag" which the isolated plant imposes on the manager, is worth so much per year and should, of course, be charged against it. Just how much this charge amounts to per kilowatt-hour or horsepower developed, or whether it has yet been reduced to a unit basis, we are not informed.

READERS WITH SOMETHING TO SAY

Best Results with Producer-Gas Engines

In looking over the Sept. 16 issue, under the heading of "Inquiries of General Interest," there is the following paragraph, being an inquiry of W. G. M.:

"What is the best average result with a producer-gas engine in pounds of coal per brake horsepower-hour?"

The answer below is given:

"About 1½ lb., but most plants use nearer two pounds."

This information is very misleading as the average gas-engine plant uses not to exceed 1¼ lb. of coal per brake horsepower-hour. My record of a plant using approximately 300 hp., for 55 hr. per week, shows for a nine months' run a consumption of 2.13 lb. of coal per kilowatt-hour, this amount including all standby losses during that time.

JOHN H. NORRIS.

Brooklyn, N. Y.

Boiler-Tube Failures

The editorial in the Sept. 2 issue on the above subject is instructive in pointing out the necessity for careful inspection at frequent intervals, particularly with regard to one of the steam user's worst enemies—oil in the feed water.

It would be idle to attempt to enumerate the frequent and well authenticated failures of boiler tubes and sheets resulting from oil being fed into boilers, even in small and apparently insignificant amounts. So long as careless engineers imagine that any return that has had the coarse or floating grease removed is good enough to use as boiler feed without further treatment, just so long shall we continue to read of cases of negligence similar to the one mentioned and, until it is indelibly impressed upon the minds of easy-going engineers that a cloudy or even slightly turbid-looking return water contains dangerous quantities of oil, just so long will the lives of firemen and others be in danger, and the property of manufacturers liable to destruction.

The editorial clearly indicated the cause of the tube failure in the instance mentioned: First, the oil separators in the steam line had not been operating effectively. Second, apparently no filter was used at all, to say nothing of a good filter as the editorial suggested.

This latter point is really the more important, as a good filter compensates for the deficiencies of the separators which are unreliable in separating the finely divided and vaporized oil.

A large majority of separators give satisfactory results only for a short time after being installed because they soon coat with a film of oil which is readily picked up again by the current of steam and carried to the feed-water heater as emulsified oil. Hence, the necessity of a filter—and a good filter.

Inasmuch as in most installations the water gets no further treatment to remove the oil, the filter should be of such character that it will absolutely remove all oil, both coarse and emulsified. If the water after passing through such filter looks hazy, cloudy or even only slightly milky, the filter should not be accepted or installed. Condensation from returns should look perfectly clear to be safely satisfactory. The use of alum or other chemicals is undesirable as constant attention is required to prevent any possibility of acids or other corroding substances getting into the boilers or eating out the valves and connections.

The importance of completely removing grease or oil from the feed water may be more fully appreciated when it is remembered that grease offers ten times more resistance to the passage of heat than ordinary boiler scale, and that the merest trace of grease, less than $^1/_{1000}$ of an inch, can cause far more serious injury than scale.

The dangers due to the presence of grease, etc., should not discourage the use of grease-impregnated water, provided an efficient separation of the oil is effected. This can now readily be done by several means, one of which is a system of absorbtion filtration, the filtration medium being a silicate fiber with strong physical attraction or affinity for oil and grease.

A. E. KRAUSE.

Jersey City, N. J.

Orsat or CO_2 Recorder Best?

Mr. Pohlman's argument, expressed in his letter under the above title in the July 29 issue, that CO_2 recorders are easily broken by inexperienced hands does not seem to apply to some of the more simple modern types.

As regards the relative value of the continuous recorder and the Orsat type, occasion may require that both should be used, for purposes of comparison.

Assume, for argument, that a given fuel burned with a minimum air should show 20 per cent. CO_2 and that the actual reading shown was 19 per cent. It is probable that the other 1 per cent. was manifested in the form of CO, showing imperfect combustion. No engineer would try to better such results. But if only 6 per cent. of CO_2 were shown, nobody would be likely to think the balance made up of carbon monoxide for, clearly, great excess air is indicated. And so, in practice, if the CO_2 is recorded above 12 per cent. the tendency is to leave well enough alone. There may or may not be a small amount of CO present, and if more air were added to correct this the overall efficiency would undoubtedly suffer. Again, if the CO_2 is in the neighborhood of, say, 9 per cent. and CO in appreciable quantity is present, effort should be made to improve the result. But the improvement would not be accomplished by admitting more air but rather by altering the furnace arrangements. Carbon monoxide is not largely

produced in boiler furnaces. When the air supplied is greatly in excess of the chemical requirements it is unlikely to be formed in a properly arranged furnace. When the CO_2 is high the monoxide even if present cannot be reduced. This fact favors the continuous recorder.

An occasional check test should be made with the Orsat apparatus. Personally, the Orsat does not appeal to me as of much use unless worked on the long-sample method, a sample taken over a long period of time. This system shows only average conditions while the recorder gives a diagram which not only can be measured up for averages but shows at very numerous intervals the varying conditions that make up the averages. And so far, the recorder is of greater value for we do not merely require averages; we want to know why the average does not approach more nearly to the best.

The Orsat apparatus should be used along with the recorder, quick samples being taken at maximum and minimum points of the recorder diagram so that the percentage of CO and of free oxygen can be found. Wherever these two gases are present together the inference must be that the mixture has been incomplete up to the time when the gases became too cold to combine. Carbon monoxide is fairly greedy for oxygen and could not remain hot in contact with it without conversion. Carbon monoxide is thus indicative of faulty mixture. It rarely happens that in boiler furnaces there is not more than enough oxygen for all purposes if only it is well distributed.

W. H. Booth.

London, Eng.

Water in the Engine Cylinder

The article in the Aug. 26 issue describing the tests made by H. Bollinckx as to water being trapped in the cylinder and doing damage is of more than passing interest inasmuch as it disproves the theory that a large percentage of the engine cylinders that are bursted are caused by entrapped water.

H. R. Low's article in the June 25, 1912, issue shows how the water may get into the low-pressure cylinder, but Mr. Low does not say anything about its getting out, and if it came from the boilers it would have practically the same chance to do damage in the high-pressure as in the low-pressure cylinder.

The tests made by Mr. Bollinckx were of such nature that if water in the cylinder could have ruptured it, it would have done so in some of the tests that he made. This would apply only to cylinders in which the exhaust valve is placed in the bottom of the cylinder, as the greater portion of the water would lie on the bottom of the cylinder, and it could not escape as readily from a cylinder on which the valve was placed on the side or top of the cylinder. In the latter case a small amount of water would very likely cause a damaged cylinder.

Every engine ought to be equipped with automatic relief cocks which would allow water to escape that should be trapped in the clearance space no matter from what source it came. Furthermore, every precaution should be taken to keep the water from going into the cylinder as it will make lubrication more difficult, even though it does no damage. An efficient steam separator should be placed in the steam line as near the cylinder as possible, and connected to a good reliable trap or steam loop, and also a large drip pocket should be placed in the exhaust line with a trap or pump connected to it to remove the condensation.

I have in mind a 30x48-in. long-range cutoff Corliss engine running at 90 r.p.m. with a variable load that pulled much water into the cylinder, due to a long steam line. There was a separator near the engine with an open drip, but at times the 2½-in. relief cocks would blow a solid stream of water at each stroke for two or three minutes at a time. In this case the water did not seem to get out of the cylinder fast enough, but a part of it was trapped in the compression space after the exhaust valve closed, and was compressed high enough to open the relief valves which were set at 20 lb. above the highest steam pressure to prevent excessive strain on the cylinder. The exhaust pipe led direct to the atmosphere with a 1½-in. drip pipe tapped into the lowest point which was left wide open all the time.

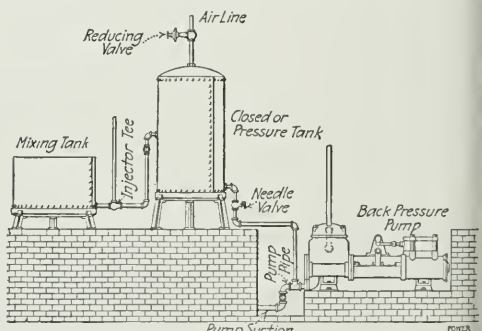
Engineers would do well to re-read these two articles as they deal directly with everyday troubles, and incidentally we will have to find some other excuse for the not infrequently bursted cylinder heads, pistons and bent piston rods that in the past have been charged up to water in the cylinder as has been done in the past for want of a better reason.

J. C. Hawkins.

Hyattsville, Md.

Feeder for Soda Ash

Readers may be interested in knowing of my experience with a compound-feeding device, similar to that described by Mr. Anderson, in the Aug. 12 issue. Having found that plain soda ash, which may be purchased for 1½c. per lb., was especially adapted for treating the



Piping for Soda-Ash Feeder

boiler water used in our plant, I decided that the best results could be obtained when this chemical was fed continuously instead of spasmodically. I, therefore, rigged up a tank for gravity feed, somewhat like the tank shown by Mr. Anderson, although this tank did not contain heating pipes. As the headroom was very small, I found that it was difficult to inject the solution into the feed pump suction pipe, so a pressure system was installed as shown in the illustration.

Sufficient chemical solution for the run is mixed in the open mixing tank, and then transferred to the closed c

essure tank by means of a steam ejector. The pressre tank is then closed and compressed air is admitted maintain a constant pressure of 5 lb. through a reducg valve. This gives a constant head on the entire sysn and enables a close adjustment of the rate at which e solution is fed through the small needle valve into the ed-water pipe. The feed is adjusted so that the boiler ater is made slightly alkaline. With this system, irgular feeding, due to changing of the solution, is elimted. I have also found that under this slight pressure, ss trouble is experienced with clogging of the needle lve.

JOHN SMITH.

Philadelphia, Penn.

Test Results for 24-Hour Run

This is a copy of the report of our average run. I ust others will submit similar reports so that we, as gineers, may be given an opportunity to compare the sults we get from our plants.

DAILY LOG SHEET—AUGUST 29, 1913

nt	C. P. & Co.
ation	Waterford, N. Y.
er heating surface, sq.ft.	5524
ed horsepower	552
e of furnace	Universal stoker
te surface, sq.ft.	100
l	Bit. run-of-mine
de name	Cascade
ration of run, hr.	24
m pressure by gage, lb.	145
perature of feed water, deg. F.	267
rees of superheat	
tor of evaporation	0.9919
st under grates	
ft in furnace, in. water	0.04
ft at dampers, in. water	0.42
p. of escaping gases, deg. F.	500
al water fed to boilers by meter, lb.	675.503
al water fed to boilers less temp. corrections of 15 per cent., lb.	574,178
ivalent evaporation from and at 212 deg. F., lb.	569,494
ivalent evaporation from and at 212 deg. F. per hr., lb.	23,728
ivalent evaporation from and at 212 deg. F. per sq.ft. heating rface per hour, lb.	4.29
rsepower developed	687.7
cent. of rated horsepower developed	124.5
al fuel fired, lb.	50,500
isture in fuel, per cent.	1
al dry coal, lb.	49,950
al combustible, lb.	45,100
r fuel per sq.ft. grate surface per hr., lb.	7.81
use by weight, per cent.	10.6
s, per cent.	12
e-gas analysis CO, per cent.	8
e-gas analysis O, per cent.	0.6
atile matter, per cent.	18.29
prox. analysis, fixed carbon, per cent.	72.78
s, per cent.	7.92
u. per lb. fuel	14,529
ciency of boiler and furnace per cent.	
oilers running without an economizer	

C. R. WARD.

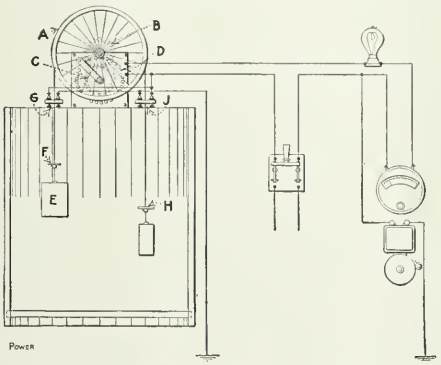
Waterford, N. Y.

Voltmeter Indicates Water Level

The plant I have charge of has a standpipe located on p of a hill a mile away, and it has always been a diffilt matter to tell the exact amount of water in the standpe by the pressure gage at the plant, for when the pump running fast the gage registers more water than is in e standpipe. When the pump is stopped and great antities of water are being drawn from the mains, the essure gage will register less than is in the standpipe. e have arranged a rheostat on the standpipe roof, which ises and lowers the voltage on the voltmeter that is lo- ted at the plant, as the water rises and falls. The voltter is calibrated in feet, so it gives the direct reading the water in the standpipe.

Referring to the illustration, *A* is a bicycle wheel ounted on a frame on the roof of the standpipe; *B* is a small gear fastened to the hub of the wheel, which meshes in the gear *C* to which is attached the rheostat-operating lever; *D* is the rheostat. As the water rises, the float *E* turns the wheel, which cuts out resistance in *D* and causes the voltage to register on the voltmeter. As the water falls it cuts in resistance and lowers the voltage, as indicated by the meter. The current is supplied to the circuit, as shown in the drawing.

When the float rises within two feet of the top of the standpipe the metal ring *F* closes the contacts *G* and



RHEOSTAT WATER-LEVEL INDICATOR

rings the bell at the plant. Then when the float gets within two feet of the bottom metal ring *H* closes the contacts *J* and rings the bell.

A. G. VINSON.

Yazoo City, Miss.

Success of Graphite in Boilers

I have read the letters from E. C. Sutton, of Estherville, and Daniel I. Curtin, of North White Plains, N. Y., telling of their experience with graphite.

I am employed by the Armstrong Cement Works, of Armstrong, Iowa, and have charge of the power plant. I have used soda ash in the boiler with success, but when we installed a new boiler, feed-water heater and pump, we had trouble with the pump clogging so decided to try graphite. Before we used graphite there was a soft substance in the pump which could easily be washed out with a strong stream of water, now since the use of graphite there is a scale about $\frac{1}{8}$ in. thick coated with graphite which adheres to the valves and springs, which keeps them from working and is also very hard to remove. I have been using my pocket knife to scrape it off.

The last time I cleaned the pump I mixed a strong solution of soda ash and put it in the pump, leaving it there about two hours, this made it easier to remove. To keep the pump in good working order it has to be cleaned every two or three weeks. The heater is cleaned once a month. There is a scale on the pans that is usually $1\frac{1}{4}$ in. thick.

From the water line down half way on the sides of the boiler the shell is coated with graphite with no scale under it but the lower half has a thin scale about $\frac{1}{32}$ in. thick with graphite. The tubes are in the same condition.

We have a graphite feeder connected with the suction pipe of the pump in which the graphite is fed continuously.

We have used graphite about sixty days. The first two weeks we used it according to directions then we doubled the dose with no better success. Before we started using graphite there was no scale in the boiler. We have some graphite left and have decided to try graphite and soda ash mixed.

Test of Valve and Piston Tightness

On page 121 of the July 22 issue is a description of a test, as above, of a Ball engine. One brief remark strikes me as being worthy of educational note—"it is plain that no steam is escaping, although it is reported that a few drops of water were discharged intermittently."

Here is a practical demonstration of one of the greatest benefits which is to be derived from the use of superheated steam—no leaks past the piston and valve-gear. When the steam is wet the moisture in it can get through the most restricted passage, but the steam itself will not escape. The steam tightness of the valves and piston of the Ball engine as described was perfect, and yet moisture could get through. How much more than "a few drops intermittently" would come past the valves and piston of an engine whose steam tightness is such as is commonly found in practice, may better be imagined than described. In a cylinder of any size it would not take long to fill a bucket.

The obvious moral is superheat if practicable, but unless there are other outside conditions dictating high degrees of superheat, remember that there is no economy in carrying the superheat to a higher degree than will enable the steam to be dry all the time it is in the engine cylinder.

John S. Leese.

Manchester, Eng.

Why Trap Failed to Drain Cans

L. Johnson asks a very interesting and instructive question in the issue of Sept. 9. It is to be regretted that he did not submit a sketch with it or give more definite information, as in its present state many things are unknown to men of much experience who would gladly help solve the question.

Was the trap a return or separating trap? Assuming it was of the return variety, was it installed in the first place beyond the receiver, or in the same relative position as the pump that it was installed to replace, and did replace later on? And, again, how much, if any, was the top of the bowl or tank of the trap when in its filling position below the outlet of the cans?

Without definite information, it would seem as if the top of the trap as first installed was very near the same level as the outlet of the cans, or possibly a trifle above it, so there was not enough head to fill as fast as necessary to keep the cans free, for it must be remembered that under certain conditions it takes a trap as long to fill as it does to empty. A pumping, lifting, or return trap, is only delivering its contents one-half the time, and it seems as if in this case the trap filled so slowly that while it was discharging the water accumulated in the cans, and when it was removed to its second position close to the cans it was set somewhat lower, or if on the same level then the mere difference in friction of the supply pipe was enough to remove the cause of disorder.

W. H. Odell.

Yonkers, N. Y.

Preventing Freezing of Air-Driven Pumps

In reply to H. R. Leonard's question, on page 138, July 22 issue, in regard to the freezing of the exhaust of an air-driven pump, I would say that the freezing is due to the presence of moisture in the air.

In a number of plants where pumps, rock drills, etc., are operated by compressed air, the moisture is successfully removed from the compressed air to obviate this difficulty. It is well known that the capacity of air to carry water vapor increases as the temperature rises, and diminishes as the temperature is lowered. What is known as "aftercoolers" are frequently used for this purpose. These are generally built like surface condensers, or coils of pipe, in which the air after leaving the compressor is cooled as low as possible by cool circulating water, after which the air is passed through a receiver or separator to remove the water that is condensed from the air. If this is properly done there seldom is much trouble from freezing. Sometimes a separator or receiver is used near the place where the air is used as the air is generally cooled down enough to precipitate most of the moisture if it is any considerable distance from the compressor.

On sinking pumps, etc., in mines a small stream of water is often allowed to drip back over the pump.

G. A. Reichard.

Los Angeles, Calif.

Stops Leak with Babbitt Metal

While in charge of a small steam plant, I was troubled with a leaky steam pipe. The leak occurred at the screw joint, which I had several times attempted to stop by screwing the coupling up tighter, by calking, and with cements, but the steam continued to escape. The pipe was so old and rusty that I could not tighten it any more, and I could not make adhesives stick permanently.

The pipe was continued from the boiler to an engine, a distance of about 50 ft. The leaky joint was just under the floor of the engine room where there was very little space for working, but, inasmuch as the joint was not visible, I decided that even a poor-looking job, if thorough, would be satisfactory.

It occurred to me that a mold could be formed around the pipe with little trouble and that if the mold were filled with hot babbitt completely around the leak, there would be no more trouble. I, therefore, bent a strip of sheet metal around the pipe at the troublesome spot, bent up the ends, puttied up the sides to render the mold leakless and poured the babbitt. Although the finished job does not look first-class, the leak no longer exists.

The method may appeal to some engineers as a means for effecting good, temporary repairs as well as permanent ones.

S. F. Wilson.

Brooklyn, N. Y.

[It would have been far better to renew the corroded pipe instead of stopping the leak as described.—Editor.]

INQUIRIES OF GENERAL INTEREST

Height for Glass Gage—At what height should a glass ter gage be placed on a horizontal tubular boiler?

W. H.

At such height that the lowest visible part of the glass l be at least 2 in. higher than the top of the highest tube the boiler.

Laying Up a Storage Battery—If a storage battery is to put out of service for an indefinite time, what attention uld it receive?

A. A. T.

Charge the battery to its full capacity and then remove acid and fill the cells with distilled water, and when again uired, refill with acid, and give the battery an overcharge; discharge the battery until the voltage is practically zero, l after rinsing with distilled water, allow the plates to .

Radius of Bumped Head—What would be the radius of a vex head which is 30 in. dia. and bumped 4 in.?

R. A. S.

Calling the radius R, then

$$R^2 = (\tfrac{30}{2})^2 + (R - 4)^2$$

$$R^2 = 225 + R^2 - 8R + 16$$

m which

$$8R = 241 \text{ or } R, \text{ the radius } = \tfrac{241}{8} = 30\tfrac{1}{8} \text{ in.}$$

Horsepower of A.C. Motor—How is the horsepower found a three-phase a.c. motor when voltage and amperage are en?

E. F. R.

The power of a three-phase motor is given by the formula

$$KW = \frac{\text{Current} \times \text{voltage} \times 1.73 \times \text{power factor}}{1000}$$

is applies to the current in any phase, and the voltage is at measured across any two of the live wires. As one rsepower is equivalent to 0.746 kilowatt, the horsepower the motor would be the kilowatts found by the formula ided by 0.746.

Running Motor as a Dynamo—Will it be possible to run a)-kw. direct-current motor as a dynamo? What changes, any, will have to be made?

E. P. B.

Any direct-current motor can be used as a dynamo. The ly difference is that when used as a motor, it has a low- sistance rheostat in series with the armature; whereas, ien used as a dynamo, it is provided with a high-resist- ce rheostat, in series with the shunt field.

If the machine is compound-wound it will be necessary to terchange the two terminals of the series field winding to event it from opposing the shunt field winding, also, it ll be necessary to speed up the machine slightly above the eed at which it ran as a motor, to compensate for the volt- e drop in the armature circuit.

Variation in Pressure Along Pipe Line—When water from pump is being discharged through a horizontal pipe line der pressure, is the pressure the same at all points along e pipe line?

M. N.

The pressure will not be the same; beginning at the pump, iction will cause the pressure to drop from point to point l along the line.

Heat Absorbed by Ice—How much heat will be absorbed a block of ice 4x6x4 ft., at 32 deg. F. in becoming melted water?

H. E. H.

Average ice weighs about 57.5 lb. per cu.ft. and a block of e size mentioned would contain 96 cu.ft. and weigh 5520 . The latent heat, i.e., the heat required to melt a pound ice at 32 deg. F. to water being 144 B.t.u. the heat re- uired would be 5520 × 144 = 794,880 B.t.u.

Steam Discharge from Pipe—What quantity of steam would be discharged per hour by a ¾-in. pipe kept filled with steam at 125 lb. boiler pressure, the open end of the pipe being submerged 1 ft. below the surface of water in a tank?

S. S. G.

The discharge would be practically the same as would be given by Napier's approximate formula for the outflow of steam into the atmosphere viz.: Pounds of steam per second $= \frac{pa}{70}$, in which p = absolute pressure in pounds per sq.in. and a = area of orifice in square inches. The absolute pressure being 125 + 14.7 = 139.7 lb. per sq.in. and as a ¾-in. dia. orifice would have an area of 0.44179 sq.in., then according to the formula the discharge would be

$$\frac{139.7 \times 0.44179}{70} = 0.8816 \text{ lb. per second, or}$$

$$0.8816 \times 60 \times 60 = 3173.76 \text{ lb. discharged per hour.}$$

Pressure After Cutting Off—With an engine having 7 per cent. clearance and cutting off at half stroke, what would be the pressure at three-fourths stroke?

D. T.

The absolute pressure at three-fourths stroke would be

$$\frac{0.5 + 0.07}{0.75 + 0.07} = \frac{0.57}{0.82}$$

or about 69½ per cent. of the absolute pressure at cut off.

Gasoline—What are the different grades of gasoline, and is there any difference in weight per quart; also how many B.t.u. are there per pound? What amount of gasoline would be consumed by an engine per hour?

J. M. H.

There is no distinct division in the grades of gasoline, it being designated according to its specific gravity, which varies from 65 to 74 Baumé scale. The heat value varies with the specific gravity from 17,000 to 19,000 B.t.u. per pound. For the four-cycle engine, under ordinary conditions, it is customary to assume a consumption of one pint of gasoline per horsepower-hour.

Measuring Temperature by Specific Heat—What is the method of determining the temperature of a furnace fire, or of flue gases by heating and cooling a piece of fire brick or other substance?

W. G. G.

A given weight of the fire brick or other substance of known specific heat, is placed in the furnace fire or flue gas whose temperature is required and after becoming heated to the unknown temperature, is plunged into a known weight of water and the rise in temperature of the water is noted. If

X = The unknown temperature of furnace or flue gas;
w = Weight of heated substance, lb.;
W = Weight of cooling water, lb.;
T = Final temperature of the water;
t = The temperature rise, or difference between initial and final temperatures of the water;
s = The specific heat of the cooled body;

the heat lost by the cooled body being equal to the heat gained by the water, then

$$ws \times (X - T) = W \times t$$

i.e.,

$$X = \frac{Wt}{ws} + T$$

The mean specific heat of fire brick for high temperatures is about 0.26 and if a piece of fire brick weighing 3 lb. were to be placed in a furnace, and heated to the temperature of the fire and then, without loss or gain of heat, is placed in a bucket containing 18 lb. of water of original temperature of 60 deg. F.; and after the immersion of the heated substance and without other loss or gain of heat, the temperature of the water rose to 150 deg. F., then the furnace temperature would be:

$$X = \frac{18 \times 90}{3 \times 0.26} + 150 = 2227 \text{ deg. F.}$$

ENGINEERS' STUDY COURSE

Heat Balance

In preceding lectures a method was given for conducting a boiler test, making and estimating the efficiency and economic results. After a test has been made the owner or engineer may be dissatisfied with the showing made. He may have been justified in expecting a better efficiency when the design, arrangement and condition of the boiler, furnace setting, etc., are taken into consideration. The test report alone does not show him in what particular the operation was poor, it simply gives final results. To get fuller information as to how the operation can be improved it is necessary to analyze the distribution of the heat contained in the coal. Perhaps in every pound of coal thrown into the furnace there was 14,000 B.t.u. available. If all this heat could be put into the water, an efficiency of 100 per cent. would be obtainable.

Unfortunately, this is impossible—some loss is bound to take place. At the very beginning, some of the burnable matter falls through the grate with the ash. Hence, all the combustible matter of the original pound of coal is not burned and, consequently, the full 14,000 B.t.u. is not generated. Next, the moisture in the coal must be evaporated and superheated and all the heat that such moisture carries out with the flue gases is lost.

The air fed into the furnace all passes out again to the chimney. True, a part of it has undergone a change (the oxygen combining with the hydrogen and carbon of the fuel) but it is all there nevertheless. This air leaves the boiler at a considerably higher temperature than that at which it entered. The heat added to it was obtained from the coal—and nowhere else. Hence, here is another loss. And so it goes; some heat radiates from the boiler and setting, and some more heat is lost through the incomplete combustion of the carbon in the fuel. Some heat is lost through unburned particles of combustible matter passing up the stack as soot, and some is lost because all the heat created by the combustion of the hydrogen in the fuel cannot be recovered in the boiler.

An itemized statement in B.t.u. and percentage of all these losses together with the quantity of heat absorbed by the water in the boiler to make steam is called a heat balance. To itemize each loss individually would necessitate considerable trouble in the way of obtaining the required data so only six divisions are usually made:

(a) Loss due to moisture and hydrogen in coal.
(b) Loss due to heat carried away by dry flue gases.
(c) Loss due to incomplete combustion.
(d) Loss due to coal dropping through grates.
(e) Heat unaccounted for (this item includes all losses not taken into consideration in the four foregoing items).
(f) Heat put into the water.

Item (a) is made up of two factors: 1, the loss of heat required to change the moisture in the coal into steam at the temperature of the gases leaving the boiler and, 2, the loss due to the fact that all of the heat generated by the combustion of the hydrogen of the fuel cannot be used for making steam in the boiler. When hydrogen burns it forms water in the shape of highly superheated steam which in the fuel calorimeter is condensed so that the latent heat of this steam passes into the cooling water surrounding the bomb (see lesson in June 10 issue) and is credited to the coal. In actual use in the boiler, however, the steam formed by the combustion of the hydrogen is partly cooled by contact with the heating surface of the boiler, but it is not cooled sufficiently to condense and, consequently, it passes off in a superheated condition at the temperature of the chimney gases. Hence, the additional heat it would give up if cooled down to ordinary temperatures and condensed is lost.

The heat given up when a pound of superheated steam at atmospheric pressure is condensed and cooled from 500 deg. to 70 deg. is exactly equal to the heat required to evaporate and superheat a pound of water from 70 to 500 deg. Hence, for simplicity and convenience it is customary to calculate the amount of water that would be formed from the estimated quantity of hydrogen in the coal and add this to the amount of moisture in the coal as shown by the proximate analysis and then calculate the heat required to raise the total quantity to the boiling point, convert it into steam and superheat it to the temperature of the escaping gases.

The first step, then, is to estimate the percentage of hydrogen in the coal, for it is seldom that an ultimate analysis is available in commercial practice. The following formula, originated by Professor Diederichs and published in POWER of Jan. 14, gives the approximate total hydrogen in the combustible matter:

$$H = v\left(\frac{7.35}{v + 10} - 0.013\right)$$

where

H = Percentage by weight of hydrogen in the combustible matter;

v = Percentage by weight of volatile matter in the combustible matter.

For illustrating the application of this formula and other calculations required in constructing a heat balance the data and results of the imaginary test reported in the Sept. 30 lesson will be used. In the calculations last week it was found that the percentage of volatile matter in the combustible was 4.37. Substituting in the foregoing formula we have

$$H = 4.37\left(\frac{7.35}{4.37 + 10} - 0.013\right) = 2.18 \textit{ per cent.}$$

hydrogen in the combustible matter. As there is only 79.84 per cent., or 0.7984 lb. combustible in each pound of coal as fired, the percentage of hydrogen in the coal as fired is only

$$(2.18 \times 79.84) \div 100 = 1.74 \textit{ per cent.}$$

or 0.0174 lb. hydrogen per pound of coal as fired.

In the lesson of May 6, it was shown that the combustion of every pound of hydrogen results in the production

of 9 lb. of water. Consequently, the combustion of 0.0174 lb. of hydrogen results in the production of

$$0.0174 \times 9 = 0.157 \text{ lb.}$$

The proximate analysis of the coal used in the test showed that in each pound of coal as fired there was 0.07 lb. of water. Then, the loss due to the hydrogen and moisture in the coal as fired is equal to the heat required to evaporate and superheat

$$0.157 + 0.07 = 0.227 \text{ lb.}$$

of water from 92 to 540 deg., the temperatures given in the test report.

The heat required to raise this quantity of water from 92 deg. to the boiling point, 212 deg., is

$$(212 - 92) \times 0.227 = 27.24 \text{ B.t.u.}$$

The heat required to change this water into steam from and at 212 deg. (latent heat) is

$$970.4 \times 0.227 = 220.28 \text{ B.t.u.}$$

And, assuming the specific heat of superheated steam to average 0.46, the heat required to superheat the steam from 212 to 540 deg. is

$$(540 - 212) \times 0.227 \times 0.46 = 34.25 \text{ B.t.u.}$$

Hence, the total loss per pound of coal as fired, due to the hydrogen and moisture, is

$$27.24 + 220.28 + 34.25 = 282 \text{ B.t.u.}$$

As the heat value of the coal as fired was 11,718 B.t.u. per lb. this loss expressed in percentage is

$$(282 \div 11,718) \times 100 = 2.4 \text{ per cent.}$$

In the present case this loss is not very high, because the coal used was of the anthracite grade in which the percentage of moisture and hydrogen never runs very high. But, with other grades, especially the bituminous and lignite, the loss runs considerably higher.

Item (b) of the heat balance is the most important because it is the largest and its magnitude depends greatly upon the skill and care used in operation.

A formula for estimating the heat lost up the chimney per pound of coal burned was given in the July 22 lesson as follows:

$$L = 0.24\ W\ (T - t)$$

where,

L = B.t.u. lost up the chimney per pound of fuel burned;

W = Weight of flue gas formed per pound of fuel burned;

T = Temperature of the gases leaving the boiler;

t = Temperature of the air entering the furnace.

The weight of the flue gases formed per pound of coal burned is estimated by another formula in the July 22 issue as follows:

$$W = 3.032\ C\left(\frac{N}{CO_2 + CO}\right) + (1 - A)$$

where

C = Weight of total carbon in the fuel as fired;

N, CO_2 *and* CO = Percentage by volume of nitrogen, carbon dioxide and carbon monoxide, respectively, in the flue gases;

A = Weight of ash in the fuel as fired.

When the volatile matter in the combustible amounts to 12 per cent. or more the total carbon in the coal as fired is found with the aid of the chart in the July 22 issue. Where it runs less, it is safe enough to assume that the volatile carbon is approximately one-third of the volatile matter. Thus, in the present case, the volatile carbon in the coal as fired would be

$$3.49 \div 3 = 1.16 \text{ per cent.}$$

and the total carbon would be, therefore,

$$76.35 + 1.16 = 77.51 \text{ per cent.}$$

or 0.7751 lb. per lb. of coal as fired. Substituting in the foregoing formula this value and the values for the flue gases as given in the test report we have:

$$W = 3.032 \times 0.7751 \left(\frac{80.2}{10.7 + 0.4}\right) + (1 - 0.1316)$$

$$= 17.85 \text{ lb.}$$

And applying this factor in the formula for heat loss we have

$$L = 0.24 \times 17.86\ (540 - 92) = 1920 \text{ B.t.u.}$$

per pound of coal burned, carried up the chimney by the flue gases. Expressed in percentage this equals

$$(1920 \div 11,718) \times 100 = 16.38 \text{ per cent.}$$

The method of calculating item (c) was given in the Aug. 5 lesson. The formula is,

$$L' = 10,150\left(\frac{CO}{CO + CO_2}\right) C$$

in which L' equals the heat loss due to incomplete combustion per pound of coal burned and expressed in B.t.u., and the other symbols represent the same values as before. The heat loss in the present case is

$$L' = 10,150\left(\frac{0.4}{0.4 + 10.7}\right) 0.7751 = 283 \text{ B.t.u.}$$

or

$$(283 \div 11,718) \times 100 = 2.41 \text{ per cent.}$$

In last week's lesson it was estimated that there was 532 lb. of combustible matter in the ash and refuse. As the heat value of the combustible was found to be 14,677 B.t.u. per lb., the total heat loss due to unburned coal dropping through the grates was

$$14,677 \times 532 = 7,808,164 \text{ B.t.u.}$$

And, consequently, the loss per pound of coal fired (item (d) of the heat balance) was

$$7,808,164 \div 10,372 = 753 \text{ B.t.u.}$$

which, expressed in percentage equals,

$$(753 \div 11,718) \times 100 = 6.43 \text{ per cent.}$$

Item (e) is the difference between the heat value of the cal as fired and the sum of all the other items.

The efficiency of the boiler and grate was found to be per cent. In other words,

$$(11,718 \times 68.98) \div 100 = 8083 \text{ B.t.u.}$$

was put into the water in the boiler to make steam. Then, item (e), representing all other losses or losses unaccounted for must be,

$$11,718 - (282 + 1920 + 283 + 753 + 8080) = 397 \text{ B.t.u.}$$

$$(397 \div 11,718) \times 100 = 3.39 \text{ per cent.}$$

All the items of a heat balance are usually arranged in tabular form, thus:

HEAT BALANCE

Heat value of 1 lb. coal as fired = 11,718 B.t.u.

Distribution of Heat	B.t.u.	Per Cent.
(a) Loss due to moisture and hydrogen in coal	282	2.41
(b) Heat carried away by flue gases	1,920	16.38
(c) Loss due to incomplete combustion	283	2.41
(d) Loss due to unburned coal dropping through grates	753	6.43
(e) Losses unaccounted for	397	3.39
(f) Heat absorbed by boiler	8,080	68.98
Total	11,718	100.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Old Sol, to whom we have always looked as an inspirer of warmth, happiness and good cheer, is in bad out Kansas way. He's been a veritable firebug during the hot spell. He'd hit a tin roof, and blim! the house burned up; he'd focus on a barb-wire and blam! a hayfield was consumed; when gathered by a lantern globe, the ancestral home was doomed before the vamps could find their fire hats. Solly, we're a bit disappointed in you.

⁂

After 700 years Roger Bacon will have a statue erected to his memory at Oxford. Bringing home the bacon is a slow process sometimes.

⁂

Petty pilferings are going on while soap is being shipped in New York for New Zealand, says a New Zealand paper. It alleges an alliance between dishonest cops and robber shipping gangs. Soap stealing sure does take the cake, but perhaps it is needed for another clean-up.

⁂

Joseph J. O'Brien, secretary of the California State Association, is the founder and editor of an interesting little monthly called "Invention." It's meaty, wise and pertinent, and should interest even the layman.

⁂

Miss Jane Addams, we have before remarked, ran second in a 10,000-name race with Thomas A. Edison as "the most useful citizen," and deservedly so. Now she is quoted as saying, "The fewer clothes we can wear, the better." Won't say another word until we hear from the lady.

⁂

Seven hundred feet below the East River, two sections of the Catskill aqueduct tunnel met—and the variation was less than half an inch! Get that inch! No guesswork in this kind of engineering eh, what?

⁂

New York's attorney-general says that electrical-plant employees are entitled to one day's rest in seven. Better talk with the boss, judge; some of us can't make him see it your way.

⁂

Out at the pumping station the employees can't get a day a week, the law's agin' it, states this same judge. "Pumpers, pump, ding ye, and keep apumpin'!" as John Foote told the band at the Springfield convention.

⁂

The Geological Survey again takes its pen in hand to remind us that gold is still worth $20.671834625323 per ounce. Thanks, fellers, thanks, but say, what does it look like, and feel like, to have and to hold an ounce of this metal?

⁂

Down in Paraguay difficulty is found in successfully raising hogs. Come on up to New York, Jose and Miguel. You might work up a good shop kink by watching the mob on the elevated roads. These hogs run wild; don't need raising. And, then, you might give us a tip on how to improve the breed.

⁂

At last we have official sanction to pin a rose on Father. The national House will make the first Sunday in June "Fathers' Day," Father to wear a rose. Mother used to "pin a rose on Me"; now, Father will make a stab at it.

⁂

Are the Damms and the Hells going to start something? We have been somewhat facetious respecting the whole Damm family, but the Hells are new to our midst. Adam Damm (sort of tautological, what?) says the Hells are trying to outbid the Damms for public attention. Further, he says there are enough Damms to sink the Hells into oblivion; enough, in fact, to patch that celebrated mile.

⁂

Waste Charged to Locomotive Heads—Headline.

Sounds like we must soon expect a head-on collision between some of the American Locomotive Co. officials. It is charged that the managers are running by signals and won't put on the brakes.

Meeting of Cotton Manufacturers

The National Association of Cotton Manufacturers held its 95th semiannual meeting at the Chalfonte, Atlantic City, N. J., on Sept. 30 to Oct. 2. It was attended by about 200 members. In addition to discussing the papers read, the meeting brought together many leading representatives of the cotton manufacturers for interchange of opinions on trade conditions and prospects.

The first session was called to order by President Edwin Farnham Greene, treasurer of the Pacific Mills and president of Lockwood, Greene & Co. Addresses of welcome were delivered by A. T. Bell, city clerk, in absence of Mayor Riddle, on behalf of the municipality, and by the Hon. Joseph W. Salus, president of the Business Men's League of Atlantic City, who said the association was "one of the most potent factors of National commerce and prosperity." Response was made by First Vice-President Albert Greene Duncan, treasurer of the Chicopee Manufacturing Co., and of Harmony Mills (Cohoes).

In his address President Greene stated that the textile industry is now entering a period of operation under conditions which exact most skillful mill management combined with the highest order of business administration. As to scientific management, the speaker said: "Any observant outsider in a casual visit to our mills may think he sees ways of economizing, but those who have been in the business realize that there are complex conditions to contend with.

Following the addresses, the president and the two guests held an informal reception which was also attended by the ladies.

On Wednesday and Thursday two daily sessions were held at which 14 papers were discussed, embracing a number of subjects which in ordinary mill organization are pertinent to power-plant management and operation.

In his paper on "Industrial Accidents, Their Compensation and Prevention," Carl M. Hansen, New York, said that "by establishing higher standards of safety and sanitation, you increase the efficiency of your workmen. All these exposed belts, shafting, gears, pulleys, clutches, couplings, setscrews, keys, pins, bad floors, and unprotected openings in floor, stairs without handrail, with bad treads and poorly lighted, insecure platforms and runways without rails and toe board, bad light throughout the plant; disorderly arranged machinery and débris littered throughout an establishment cause great loss in the productive efficiency of your employees."

L. H. Kunhardt, vice-president and engineer of the Boston Manufacturers' Mutual Fire Insurance Co., in his paper, "Preservation of Life in Factory Fires," stated that "the larger factories have given most serious consideration to the matter of self protection with the result that they have been almost entirely free from loss of life when fires occur. The most vital factor in preventing loss of life and property is the automatic sprinkler, and this alone will render the great majority of fires harmless to life and of small damage to property, but there must be secondary safeguards briefly covered by the general name 'slow-burning construction,' which means brick or equivalent walls, solid floors without openings between stories, stairs in outside towers, elevator and other openings protected and safe arrangement of processes. Then, even if very rarely sprinklers fail for any cause, the spread of fire will be so retarded that the operatives can escape without harm."

Speaking on the topic, "Methods of Cost and Clear Accounting Essential to Efficient Mill Management," Clinton H. Scovel said that the equipment in each production center represents an investment of capital; requires the payment of taxes and insurance; it suffers depreciation, and it incurs charges for power, repairs, such indirect items as superintendence, inspection and helpers' services. If the mill shuts down, the power may be shut off and the overseers and second hands dismissed; but so long as it runs, however short-handed or inefficient, these charges do not change materially. Very few mills have calculated the burden element in cost with any degree of precision, and it is not necessary that a business should be approaching failure in order to have work of this kind highly profitable.

In a paper on "Developments in Lubrication," W. F. Parish, New York City, claimed that the rule is that within limits a reduction in the viscosity of a lubricant will bring about a reduction in the coefficient of friction, or a reduction in temperature and in lost power. Most of the resistance or lost power in running machinery is caused by the internal friction or the fluid friction in the lubricant used, assuming that an average condition with an average oil is under consideration. It is only occasionally, through the use of a very improper oil or lack of feed of a proper oil, that actual metal

wear on properly constructed bearings takes place. Wherever bearings are flooded, or where a proper working oil film is maintained, a very large proportion of the frictional loss is directly due to the internal fluid friction of the oil itself, and this can be influenced one way or another along certain prescribed lines.

In working entirely with paraffin base oils the coefficient of friction is influenced directly in proportion to the rise and fall of the viscosity of the oil used, always within the limits of speed and pressure. Working with oils made from the new Southern or Texas asphaltic base crudes the same general rule also applies.

"I have the honor," said Mr. Parish, "to present for the first time scientific and practical tests and investigations which show that, while the general law of the relation of viscosity to power is applicable to lubricants made from any one crude or classification of crude, a modification is necessary when tests on oils made from the paraffin base crudes are compared with tests on oils made from the new Texas base crudes. This technical feature of the Texas base oils is of the utmost importance, not only from a scientific, but from a practical standpoint.

"The great technical advantages in being able to use a heavier-bodied, higher-viscosity oil for lubrication are obvious. Less oil of this kind will be used, as it will not flow as rapidly from the oil can or cup. In the case of textile-mill work, a heavier-bodied oil will not drip as rapidly from the boxes or shafting. When the plant is closed down, the heavier-bodied oil will have a greater tendency to stay between the surfaces, so that in starting, the initial friction or power will be better influenced. The lighter-bodied oils at times when the machines are at rest, drip out or are pressed out between the surfaces, and high temperatures result upon starting the machines, owing to the fact that little or no oil is present between the surfaces to be lubricated during the start and until the oil boxes or cups are brought into operation. Where it is possible to use a heavier-bodied oil of higher viscosity, this effect is not as pronounced."

A paper on "Advantages of Commercial Motor Cars in Cotton Manufacture," by Day Baker, of Boston, Mass., was well illustrated by the stereopticon. The views showed the extensive use made of trackless electric-motor vehicle work for indoor and outdoor industrial transportation. Referring to the advantages of electric over other forms of motor vehicles, Mr. Baker said that while the current for the charging of the batteries is figured in all commercial estimates at 4c. per kw.-hr., most mills or factories can operate a small waterwheel or small engine during the night, furnishing power to charge the batteries, or taking current from the lighting plant before the peak of the load, utilizing capacity of a power equipment which would otherwise be idle and unproductive, thus reducing the cost of current to a small fraction of a cent per kilowatt-hour.

"Care of Belts," by Dudley Wilcox, Hartford, Conn., had an interesting reference to a scientific method of inspection of the tension of small belts. It also described a portable apparatus for determining the proper amount for cutting out of the length of belts for obtaining a tension which will be within the elastic limit of belt strength and not productive of unnecessary journal friction.

"It has been proved conclusively by a series of experiments lasting over nine years," continued Mr. Wilcox, "that tension of belts has more to do with their life than any other one factor.

"The average leather belt during its life stretches at least 6 per cent. of its original length, stretching rapidly from the beginning till a period of four to twelve months has elapsed, then a stretching almost uniformly for a number of years dependent upon the care it receives until finally its elasticity is practically gone, and the question arises whether it is cheaper to keep on repairing it every week or two or to buy a new belt. It has been found that belts well proportioned for the work required of them need tightening at intervals of two to six months.

"Because of these conclusions and the usual lack of uniformity in the care of belts, a system and apparatus have been devised by means of which belts may be cared for in the most economical manner and interruptions to manufacture, due to failure of belting, may be reduced to a minimum.

"When this belt system was first applied in mills, a bench was built for weighing the tensions of belts by means of spring balances, and periodically all belts in the shop had to be brought to the bench for inspection and repair. With this inconvenience in mind, a portable device has been perfected for measuring the tensions of small belts while in place on their pulleys.

Group of Officers, Members and Guests at Meeting of National Association of Cotton Manufacturers, Atlantic City, N. J., Oct. 1, 1913

"It consists of three parallel steel rollers about 4 in. long by 1 in. in diameter, spaced about 10 in. apart and having one end of the axle bolt of each connected with a frame. The two end rollers have their axles fixed rigidly to the frame, while the spindle of the central roller is fastened to a slide on the frame and moves in a plane at right angles to the plane of the other two axles. This movement is controlled by a compression spring pressing the axle bolt of the movable roller against a cam revolved by a handle. When the handle of the apparatus is turned a weighing spring presses the middle roller gainst the belt, flexing it, and showing the tension of the belt on the graduated rod.

"By means of this device, the tensions of all belts up to 4 in. wide may be measured accurately while belts are in working position over their pulleys. With it belts may be inspected in about a quarter minute each and the amount necessary to be removed to bring the belt up to its proper maximum tension is indicated directly on the scale."

"Purchasing Coal Under Specifications" is the subject of a paper presented by George S. Pope, engineer-in-charge of government fuel inspection, Bureau of Mines, Washington, D. C., to be published in an early issue.

Illuminating Engineers Meet

The Illuminating Engineering Society held its seventh annual convention at Pittsburgh on Sept. 22 to 25, with headquarters at the Hotel Schenley. The meeting was called to order by Chairman C. S. Littlefield, and W. H. Stevenson, president of the Pittsburgh Chamber of Commerce, made an address of welcome to which President Millar and Vice-President Macbeth responded.

One of the features of the meeting was the presentation to the society by Prof. Hoadley, of a historic gavel symbolic in its design of the development of artificial illumination in this country up to the present time.

The report of the committee on progress completed the business of the morning session.

In the afternoon presentation of papers began and extended over Tuesday, Wednesday, Thursday and part of Friday. Following is a list of the papers presented:

"Recent Improvements in Incandescent Lamp Manufacture," by Ward Harrison and E. J. Edwards; "The Cooling Effect of Leading-In Wires Upon the Filaments of Lamps of the Street Series Type," T. H. Amrine; "Modern Practice in Street Illumination," S. G. Hibben; "Hospital Lighting," William S. Kilmer; "The Efficiency of the Eye Under Different Systems of Illumination—The Effect of Varying the Distribution and Intensity of Light," Dr. C. E. Ferree; "The Psychological Values of Light, Shade, Form and Color," Dr. F. Park Lewis; "Some Theoretical Considerations of Light Production," W. A. Darrah; "The Use of Nitrogen at Low Pressure in Tungsten Lamps," G. M. J. Mackay; "The Neon Tube Lamp," M. George Claude; "The Quartz Mercury Vapor Lamp and Its Application," W. A. D. Evans; "The Evolution of the Lamp," Roscoe E. Scott; "Description and Demonstration of the Lighting of Soldiers' Memorial Hall"; "Church Lighting," R. B. Ely; "Experiments in the Illumination of a Sunday School Room with Gas," Edwin F. Kingsbury; "Distinctive Store Lighting," C. L. Law and A. L. Powell; "Factory Lighting," M. H. Flexner and A. O. Dicker; "Some Commercial Aspects of Gas Lighting," J. E. Philbrick; "The Lighting of Show Windows," H. B. Wheeler; "The Illuminating Engineering Laboratory of the General Electric Company at Schenectady," S. L. E. Rose; "The Pentane Lamp as a Working Standard," E. C. Crittenden and A. H. Taylor; "The Photo-Electric Cell in Photometry," Prof. F. K. Richtmyer; "Some Studies in Accuracy of Photometry," Evan J. Edwards and Ward Harrison; "Characteristics of Enclosing Glassware," Van Rensselaer Lansingh.

On Wednesday evening a banquet was held at the Hotel Schenley. G. H. Harries acted as toastmaster, and among the speakers were President P. S. Millar, President-elect C. O. Bond, C. M. Bregg and J. A. Brashear.

The present membership of the society is 1350.

SOCIETY NOTES

Pratt Institute, Brooklyn, N. Y., has opened an evening course in trade teaching. The directors believe that there is a strong demand for men with trade experience as teachers in industrial and trade schools. Particulars may be had by addressing Director Samuel S. Edmands.

At a regular meeting of Minneapolis Association No. 2, Minneapolis, of the National Association of Stationary Engineers on Sept. 28, State President-elect H. F. Mueller was installed by State Deputy T. S. F. Hayes. The recently returned delegates to the national convention at Springfield, Mass., gave interesting reports of that event, and President Morris, on behalf of the delegates, formally presented the association with the silk altar flag awarded it for the large increase in its membership during the past year.

OBITUARY

JOHN F. ENSIGN

On Sept. 25 John F. Ensign, chief of the division of locomotive boiler inspection of the Interstate Commerce Commission, died in Washington, D. C., at the age of 51 years. His wife and daughter accompanied the body to Denver, Colo.

Mr. Ensign was the first man to fill the position of boiler inspector, having been named for that place July 1, 1911, by President Taft, the day the law went into effect. Mr. Ensign was born in Marathon, N. Y.

PERSONALS

O. W. Watson has been appointed superintendent of the Leicester plant of the Worcester (Mass.) Electric Light Co.

E. M. Westhoven has been appointed superintendent of the Woodlake station of the Mount Whitney Power & Electric Co., of Visalia, Calif.

Frank J. Corbett has opened an office at 30 Church St., New York City, for the sale of condensers, pumps, cooling towers and other apparatus used in the power field.

S. M. Udale, formerly assistant research engineer with the Studebaker Corporation, is now in charge of the laboratory and motor-testing plant of Joseph Tracy, whose New York office is in the United States Rubber Building, 1790 Broadway, New York City.

Joseph Harrington has resigned his position as chief consulting engineer for the Green Engineering Co. and engaged in independent practice. He will specialize in boiler-plant work, such as improving plant design, equipment and operation and increasing organization efficiency. Mr. Harrington was connected with the Green Engineering Co. for 12 years.

Thomas R. Armstrong, of Boston, recently appointed a number of the Massachusetts Board of Boiler Rules to represent the operating engineers of the state, was selected and recommended to the governor by the New England Society of Superintending Engineers, whose members are the chief engineers of the large plants of the state. The society also recommended the appointment of George Luck, the new chief inspector of the boiler-inspection department. Mr. Armstrong is an engineer of large practical experience, having been a commissioned engineer in the United States revenue service, an engineer officer in the United States Navy, and a chief engineer of ocean-going vessels in the merchant service. He has also held the positions of chief engineer of Boston public institutions; of the Sears estate, Boston; of the Mason Machine Works, Taunton, Mass.; an inspector of engineering materials for the Japanese government at the Cramps shipyard, at Philadelphia; superintendent of construction for the C. E. Cotting estate, Boston. Mr. Armstrong is at present chief engineer of the Boston Safe Deposit & Trust Co.; chief engineer-in-charge of the U. S. S. "Chicago," "Rodgers" and the "Macdonough," which vessels are attached to the Massachusetts Naval Brigade. He holds the rank of lieutenant-commander. Much credit is due the officers and members of the New England Society of Superintending Engineers in selecting an engineer so well qualified to represent the engineers of Massachusetts on the Board of Boiler Rules.

⁂

The National Tube Co.'s bulletin No. 16 deals with tests applied to boiler tubes. The manner in which the tubes are tortured is shown by numerous halftone engravings, and a table of dimensions, weight, and test pressures is given. The bulletin is worth sending for. It may be had free upon application to the Pittsburgh office of the company.

⁂

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

of Power, published weekly at New York, N. Y., required by the Act of August 24, 1912.

Editor, Fred R. Low, New York, N. Y.
Managing Editor, H. R. Cobleigh, New York, N. Y.
Business Manager, William Buxman, New York, N. Y.
Publisher, Hill Publishing Company, New York, N. Y.
Owners, Hill Publishing Co., 505 Pearl St., New York, N. Y.

Owners of 1% or more of Stock Issued.

John A. Hill, 505 Pearl St., New York, N. Y.
Fred R. Low, 505 Pearl St., New York, N. Y.
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Fred S. Weatherby, 1600 Beacon St., Boston, Mass.
Frederick A. Halsey, 505 Pearl St., New York, N. Y.
G. Eugene Sly, 50 Union Sq., New York, N. Y.
Frederick W. Gross, 447 E. 11th St., Erie, Pa.
Alfred E. Kornfeld, 114 E. 71st St., New York, N. Y.
Emma B. Hill, 80 Munn Ave., E. Orange, N. J.

The balance of the stock issued (less than 1% each) is owned by 62 employees, one ex-employee, and 11 others who are wives, daughters or relatives of employees.

There are no bondholders, mortgagees, or other security holders.

C. W. Dibble, Vice-President.
HILL PUBLISHING COMPANY.

Sworn to and subscribed before me this 29th day of September, 1913.

RICHARD L. MURPHY,
Notary Public.
(My commission expires March 30, 1915)

POWER

Vol. 38 NEW YORK, OCTOBER 21, 1913 No. 17

"The Power Man"

By Berton Braley

Beyond the "utmost purple rim"
You're certain to discover him,
All khaki-clad and lean and brown
And eager for the news of town,
But having chiefly on his mind
The keen desire to seek and find
A head of water that will do
To hitch a bunch of turbines to.

You run across the "power man"
In Arkansaw or Martaban,
Or clad in true explorer's style
And seeking sources of the Nile;
His stubborn aim, his constant dream
Is hitching up some roaring stream
And getting from its rush and roar
Ten thousand horsepower—maybe more,
Where nary horsepower was before!

He's somewhat lacking in romance
A waterfall he views askance
No matter how or where it's placed
He says—"There's power gone to waste
One hundred thousand h.p. loose
Which should be put to some good use.
Not lost in spray and roar."
A torrent tumbling o'er the brim
Is wasted energy to him,
And it is nothing more.

He breaks the trail through palm and pine
For power house and railroad line,
And on his footsteps cities press
And sweep away the wilderness,
But he goes on and on and on
Toward the sunset or the dawn
With mind and heart and soul intent
On harnessing a continent,
By turning every stream he can
To power for the use of man.
One single thought is on his mind
The keen desire to seek and find
A head of water that will do
To hitch a bunch of turbines to.

Lentz Engines in Baltimore Office Building

By Warren O. Rogers

SYNOPSIS—Power plant of the best office building in Baltimore, Md. Three Lentz poppet-valve engines supply power for the building service. The power plant also consists of elevator pumps, vacuum-cleaning apparatus, an absorption refrigerating system, also pumps for hot- and cold-water and fire service.

The new fireproof office building of the Maryland Casualty Co., Baltimore, Md., is pronounced the best equipped and most beautiful building in the city. It was decided to erect a new office building about a year prior to the great Baltimore fire in 1904, and work was begun

Fig. 1. Home Office Building of the Maryland Casualty Co.

immediately after the fire, with the result that the building shown in Fig. 1 is now the home of the company. The original building was three stories high, later two stories more were added to it and in 1911 the addition shown by the tower was constructed.

The building is located in the heart of the city with a frontage of 100 ft. on Baltimore St. The tower is 41 ft. square and rises to an observation platform 230 ft. above the street level. The height of the highest point, the crow's nest, is 349 ft. The tower is 18 stories high.

All mechanical equipment is in the basement and represents the latest design of power-plant apparatus. Owing to the restricted ground area considerable forethought was necessary in order to install the power plant and mechanical equipment required, and at the same time keep down the first cost and subsequent maintenance costs.

Engine Room

In the engine room, Fig. 2, are three poppet, four-valve engines having 12x18-, 13x18- and 16x21-in. cylinders respectively. These engines are directly connected to 50-, 75- and 125-kw., 125-250-volt, compound-wound, interpole direct-current generators.

A comprehensive idea of the finish of the plant is obtained from Fig. 2. The engines are placed on white glazed brick. The floor is of tile. The walls and ceiling are painted white with a dark-green wainscoting. All paint work is varnished, which facilitates greatly in keeping the room clean as this finish permits of washing. All machinery is painted a maroon color and tastily striped.

So quietly do the engines run that one is reminded of the sound of a new sewing machine. The three sizes of units give a flexible power plant and permit of operating the engines at their most economical loads. At the time of this writing one unit is sufficient to carry the load of the entire building. As the load increases with shorter days an additional unit can be started up to take care of it, the size of units being operated depending upon the load.

Boiler Room

Steam is supplied to the engines, pumps, etc., from three 150-hp. water-tube boilers, Fig. 3, fitted with superheaters designed for a pressure of 180 lb. of steam. The working pressure is 140 lb. The superheaters are damper regulated and deliver steam at a temperature of 100 deg. superheat. The boilers depart slightly from the standard design, as it was necessary to place them in a certain available space, somewhat restricted in width. Each boiler contains 1480 sq.ft. of heating surface. The furnaces are flush front and fitted with mechanical stokers. The size of these furnaces is 4½x6 ft., but when installed they were so arranged that the actual grate area is 4½x5 ft., thus making a grate area commonly used with a 125-hp. boiler. These furnaces are guaranteed to burn sufficient fuel to develop at least 35 per cent. more than the boiler rating. The stokers are operated by a stoker engine, which is hand regulated.

Each boiler has 83 tubes 3½-in. by 18-ft. long and one drum 36 in. in diameter. There is a soot-blower system attached to each boiler which is included as part of the boiler equipment. The furnace draft is regulated by a damper in the smoke flue and is controlled by a damper regulator. The steam gages are of the illuminated type, using red incandescent lamps, which makes an easy color by which to read the steam pressures indicated. Drop lights properly shielded illuminate the water glasses.

A receiver for the returns is located in the boiler room, also the feed-water heaters, two 6 and 4 by 6-in. boiler-feed pumps, coal-weighing outfit and hydraulic ash lift. Coal is delivered from the street surface to a coal hopper, arranged under the inlet opening in the street. It is then weighed and dumped into a coal bin below through sliding gates in the bottom of the hopper. These gates are operated by a lever from the boiler room. The floor and walls of the boiler room are of concrete. The walls are painted pea green with a marine-green wainscoting.

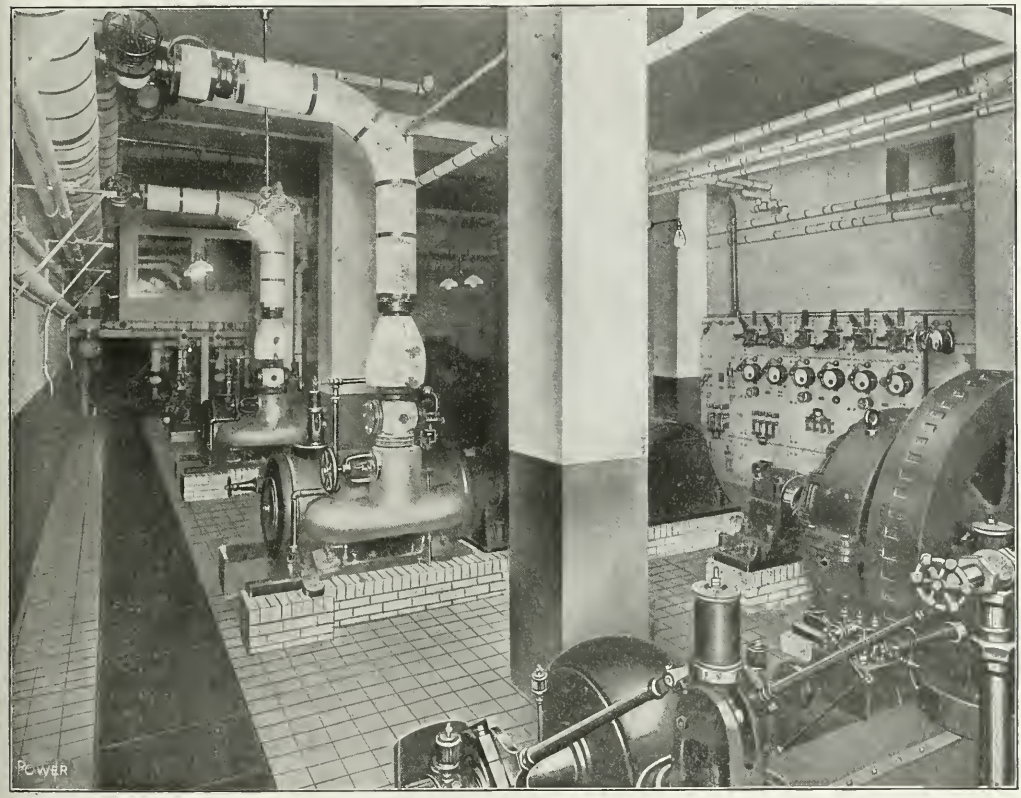

Fig. 2. Three Lentz Poppet-Valve Engines

The fireman is furnished with a toilet in one corner of the boiler room.

Each boiler steam drum is fitted with a blow-down pipe as is also the mud drum, both being fitted with a blowoff valve. These two pipes are connected to a main blowoff pipe, which is fitted with a third blowoff pipe.

Steam Mains

There are two steam mains from the boilers to the engines and auxiliary units. One is 4 in. in diameter and under ordinary conditions supplies steam to the 75-hp. engine, pumps, etc.; the other is an 8-in. main and supplies the other two engines. Bypass connections, however, make it possible to cut out either line and still operate the engines and pumps. The small unit is piped to both mains. All piping is suspended from the sidewall upon brackets, as shown in Fig. 2, and is protected by suitable pipe covering.

At the center of the engine room, which is 144 ft. long and 30 ft. wide, are two 8 and 10 by 12-in. vacuum pumps, used in connection with the heating system.

For fire protection there is an Underwriters Standard duplex fire pump, size 16 and 9 by 12 in., with a capacity of 750 gal. per min. at 70 r.p.m. It is connected to a 5-in. hose standpipe which extends to the eighteenth story. From this standpipe there is a 2½-in. fire hose connection on each floor. The two 5¼x3½x5-in. cold-water house pumps are also connected to the standpipe and can be used on the fire system if occasion arises.

A view of the elevator pumps and a portion of the refrigerating system is shown in Fig. 4. Elevator service is provided for the building by five hydraulic plunger passenger elevators, one of which is a combination passenger and freight car, two of the elevators run to the fifth floor only, which is the height of the main building. The other three elevators provide express service for the tower floors. They have the longest run of any plunger elevators in Baltimore.

The pumping plant for the elevator service consists of two 12, 18 and 11 by 18-in. compound, piston-valve,

duplex, outside end-packed plunger pumps, one of which is used for regular service and the other for relay. There is also a small 5¼ and 3½ by 5-in. piston-valve, duplex, outside-end-packed plunger pump for lifting safes and other heavy loads. The 9½ and 8 by 10-in. air pump is of the water-jacketed type. The pressure and discharge tanks are constructed of ¾-in. steel designed for 175 lb. pressure per sq.in. Each is of 7500 gal. capacity, the

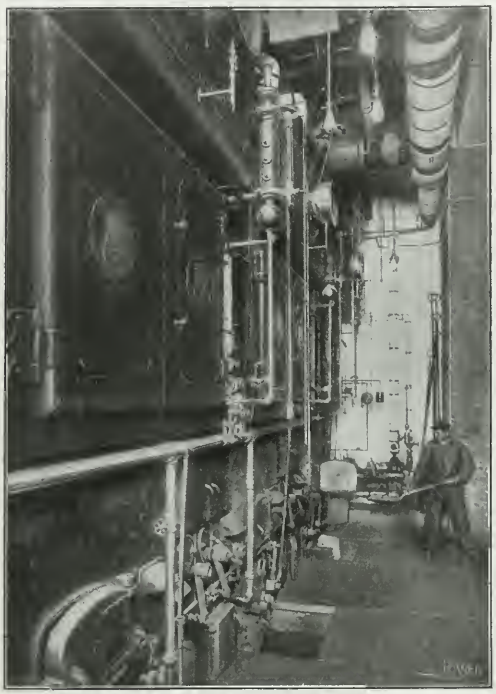

FIG. 3. FIRING FLOOR IN BOILER ROOM

pressure tank carries a pressure of 150 lb. The seams are of the quadruple-riveted, double-strap, butt-joint type.

A 10-ton absorption refrigeration system furnishes iced drinking water throughout the building and also cools the refrigerating chest in the kitchen on the seventeenth floor. A complete system for vacuum cleaning has also been installed, with all the outlets, brushes and other

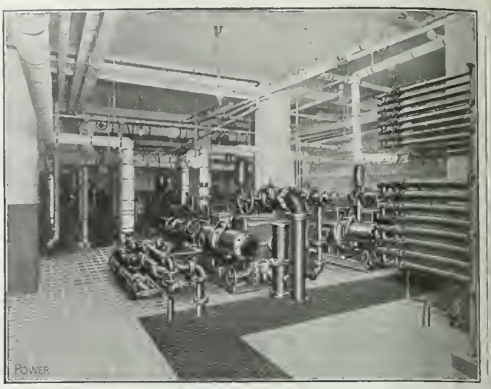

FIG. 4. ELEVATOR PUMPS AND PARTIAL VIEW OF REFRIGERATOR SYSTEM

paraphernalia necessary for an efficient system. A 15-hp., 230-volt motor running at 3400 r.p.m. is directly connected to a turbine vacuum cleaner.

SWITCHBOARD

The main switchboard, 24 ft. long and 6 ft. 8 in. high, is made in nine panels of blue Vermont marble. There is the usual power panel for each generator and one main distributing panel. The other panels are for controlling the various circuits throughout the building. In addition to the usual instruments there are three wattmeters and one special graphite wattmeter.

Attached to the switchboard is a pilot clock which operates in conjunction with the tower clock and shows whether the latter is running ahead or behind, thus permitting of regulating the clock without leaving the engine room.

The building is heated by a modern vacuum-return system, exhaust steam being used during ordinary cold weather, but with severe cold it is necessary to help out with live steam, as the low steam consumption of the engines does not supply enough exhaust steam to heat the building. All water used in the building for drinking, washing boilers and for other purposes is passed through a battery of water filters.

The design and installation of this plant was under the supervision of J. W. Rausch, manager of the boiler, flywheel and inspection departments of the company, to whom the author is indebted for photographs and data.

PRINCIPAL EQUIPMENT OF THE MARYLAND CASUALTY CO.'S NEW POWER PLANT.

No.	Equipment	Kind	Size	Operating Conditions	Manufacturer
1	Engine	Lentz	12x18″	Main unit, 75 hp., 200 r.p.m., 140 lb. steam	Erie City Iron Works
1	Engine	Lentz	13x18″	Main unit, 115 hp., 225 r.p.m., 140 lb. steam	Erie City Iron Works
1	Engine	Lentz	16x21″	Main unit, 190 hp., 200 r.p.m., 140 lb. steam	Erie City Iron Works
1	Generator	Direct current	50 kw.	Main unit, 125-250 volt, 200 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Generator	Direct current	75 kw.	Main unit, 125-250 volt, 225 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Generator	Direct current	125 kw.	Main unit, 125-250 volt, 200 r.p.m.	Westinghouse Elec. & Mfg. Co.
3	Boilers	Water tube	150 hp. 1480 sq.ft. h.s.	Main units, 140 lb. steam superheat 100 deg.	Heine Safety Boiler Co.
3	Stokers	Murphy	4½x5 ft.	Boiler furnaces; flush fronts	Murphy Iron Works
3	Blowers	Bayer		Blowing boiler tubes	Bayer Soot Blower Co.
1	Regulator	Spencer		Damper control	Spencer Regulator Co.
1	Scale	Hopper		Weighing coal	Fairbanks Co.
2	Pumps	Duplex	6x4x6″	Boiler feed	Epping-Carpenter Co.
2	Pumps	Duplex	16x9x12″	Heating system	
1	Pump	Duplex	8x10x2″	Fire system	Buffalo Steam Pump Co.
2	Pumps	Duplex	5¼x3¾x5″	Cold water house service	Epping-Carpenter Co.
5	Elevators	Plunger		Passenger and freight	Standard Plunger Elevator Co.
2	Pumps	Duplex	12x18x11x18″	Elevator service	Epping-Carpenter Co.
1	Pump	Duplex	9x5x10″	Elevator service	Epping-Carpenter Co.
1	Pump	Water jacketed	9½x8x10″	Elevator system	Westinghouse Air Brake Co.
1	Refrigeration system	Absorption	10 ton	House and kitchen	Carbondale Machine Co.
1	Motor	Direct current	15 hp.	Vacuum cleaner motor, 230 volts, 3400 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Cleaner	Turbine		House vacuum cleaner	Spencer Turbine Cleaner Co.
1	Switchboard	Marble		Nine panel	Westinghouse Elec. & Mfg. Co.
1	Filter system	Battery		House water filter	Loomis-Manning Filter Co.

Barometric Condenser Piping

By B. S. Nelson

SYNOPSIS—*Directions are given for properly piping a barometric condenser for reciprocating engines. There should be two strainers in parallel on the injection pipe.*

The barometric condenser in which the vacuum is produced and maintained by the fall of a column of water in the tail pipe is so simple and satisfactory when properly installed and operated, that for cases where a very good vacuum is not essential it seems strange that it is not more universally used.

In irrigation plants the conditions are particularly favorable for a barometric condenser, as the load is uniform for long periods, varying only with the stage of the canal or intake from which the pumps take water. The pump units are usually driven by cross-compound engines where a vacuum of 27 or 28½ in. is as high as is necessary for good economy, especially since the injection water is usually warm, around 80 deg. F., for all pumping is done in the summer months. Then, again, as it lifts which are usually in the neighborhood of 20 to 25 ft., it is possible to get sufficient siphon action from the discharge flume to provide injection water without the use of a small pump; in other words, the main pump, with its high economy, pumps the cooling water instead of a small wasteful auxiliary. Fig. 1 shows a typical barometric-condenser installation in an irrigation plant. It is well known that without proper precautions in designing the piping the condenser becomes a source of danger, due to possibility of flooding the engine cylinder when starting up or running on very light loads. The

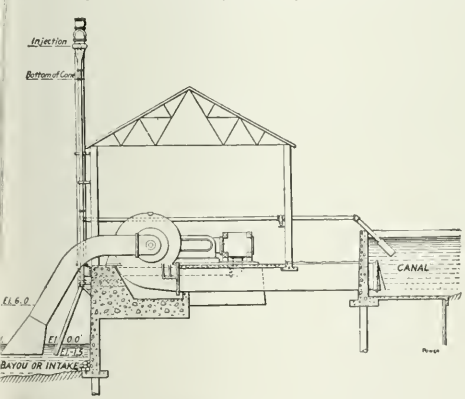

Fig. 1. Elevation, Barometric Condenser Installation

writer's experience has proved that the piping arrangement shown in Fig. 2 is excellent in practice where a rejector is used. The size of the main pipes and the ght of the cone above the overflow are not shown in drawing. It is good practice to run the tail pipe directly into the intake instead of using a hotwell with overflow.

It is advisable to so place the condenser that the bottom flange of the cone is 34 ft. above the high-water line in the intake, or if a hotwell is used, above the overflow which allows the height of the condenser as leeway, to prevent possible flooding. Theoretically, 34 ft. from injection to overflow is enough, but the water in the tail pipe contains air; therefore it is lighter than solid water.

It is best to use the sizes of injection and tail pipes recommended by builders for each particular condition, and they should never be smaller than companion flanges

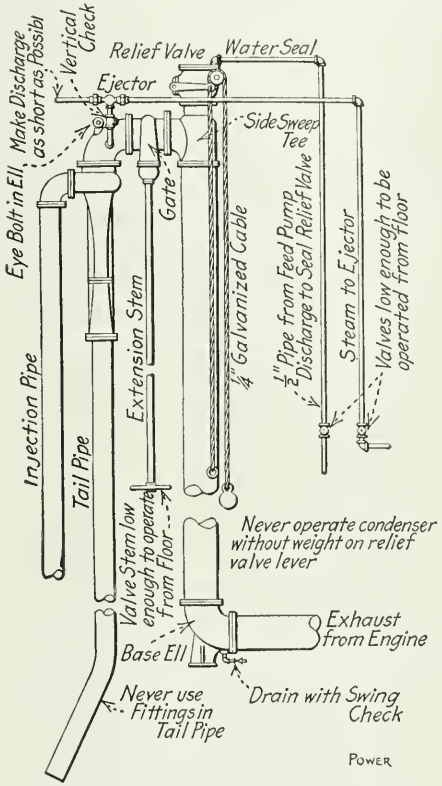

Fig. 2. Details of Barometric Condenser Piping.

call for, provided the condenser used is not too big for its work. Then reduction should be made with tapered reducers, not with bushings. The injection pipe should be provided with a strainer of ample size, preferably two in parallel, and also a valve to control the water-supply.

Referring to Fig. 2, the exhaust pipe should have a slight fall toward the riser and at the lowest point of the ell at the riser, which should be a base ell; an automatic drain, consisting of a 1¼-in. check valve opening out, should be installed without a valve between it and the air. At the top of the exhaust riser is a reducing tee, on the small end of which is connected an automatic relief valve. This can be one or two pipe sizes smaller than the main exhaust, due to the smaller volume of steam at atmospheric pressure; that is, a 14-in. exhaust

would take a 12-in. relief, a 10-in. exhaust an 8-in. relief, etc.; and should always be of the closed type, so it can be water-sealed by a ½-in. pipe as shown.

The relief valve should have a wire cable to the floor for opening by hand; this cable should be weighed with a ball equal to 5-in. vacuum to prevent chattering on the seat which will quickly ruin the valve.

For example, a 10-in. valve should have a pressure on the disk roughly equal to 190 lb., which would probably mean a smaller weight, as the disk is held by a longer lever arm to which the cable is attached. On the tee outlet there should be a gate valve, then the condenser elbow. It has been found most satisfactory to point the stem of the valve down and use an extension stem to operate it from the floor. Many installations omit this valve, which is so essential both for starting up properly and for repairing the condenser while the engine is running.

The illustration shows a small ejector for priming the condenser, which is used in cases where the condenser siphons its water to start it flowing. Where a pump is used to supply water this is not necessary.

In starting the unit, the engine is first started with the gate valve to the condenser shut, and is so brought up to speed. In the meanwhile, the condenser is being primed by the ejector, or the supply pumps started, and when the water starts to flow, the gate valve to the exhaust is slowly opened. Then the valve in the injection line is manipulated until the best vacuum is attained, which is usually with the valve partly closed.

In conclusion, it is well to mention that, a good strainer should be used. The main trouble with barometric condensers is due to air leaks at the flanges, relief valve, or low-pressure stuffing-boxes. It is well to test these joints with a candle occasionally.

For supporting small condensers up to about 10 in. or 12 in., it has been found satisfactory to use a base ell on the exhaust and injection risers, and let the condenser rest on them, the whole outfit being braced to the building wall by A-braces. For larger condensers, there must be either a tripod for the base flange of the tail pipe or a special fitting with lugs may be fastened to the tail pipe. In no case should a base ell, or any other sort, be used in the tail pipe. If the pipe must have angles use bends.

Boiler Attachments—II.

By J. E. Terman

SYNOPSIS—The proper location and pipe connection of the steam-gage are discussed, also the correct and incorrect connection of the blowoff pipe and valves. The application of the surface blowoff is also set forth.

The only boiler attachment that can be safely connected to the pipe connecting the water column to the steam space of the boiler is the steam-gage, since there is no flow of steam required for its operation. No valve should be allowed between the steam gage and the boiler it is to serve, except the small cock used immediately below the gage. The handles on these cocks always show at a glance, whether they are opened or closed. The foregoing requirements do not apply to steam-gages used on the steam main, or in the engine room, but only to the individual gages on each boiler. Every boiler should be equipped with an individual steam-gage, except in case of two or more boilers connected by steam and mud drums, so that they are necessarily always operated together as a single unit. In this case, a single steam-gage connected to one boiler of the battery is sufficient.

The modern steam-gage is dependent on the action under pressure of a Bourdon spring to produce registrations. This spring consists of a flattened tube bent in the form of a coil, which tends to straighten when subjected to internal pressure. The Bourdon spring is affected by temperature as well as pressure, so it is necessary to protect a gage from any serious changes of temperature, if its registrations are to be correct.

To prevent the steam gaining access to the spring, the gage must be arranged so that a water pocket will be formed in the piping connecting it to the boiler. Where small, light gages are used, which are supported entirely by the connecting pipe, it is usual to provide this pocket by turning a goose neck in the pipe, as shown in Fig. 7.

Where the gage is heavy and is fastened to some portion of the boiler front or setting, or to the building, the piping is usually arranged to drop down toward the gage from some higher point, and thus form a trap for collecting sufficient condensation to protect the gage spring. External heat will affect the spring the same as if applied internally, therefore the gage should not be fastened directly to any surface that is likely to become unreasonably hot, such as the breeching or the portion of the front above the tube doors. Where it seems advisable to fasten a steam-gage to such parts, it should be thoroughly insulated with sheet asbestos or similar material, and in addition an air space of an inch or two should be left between the gage-case and the surface to which it is attached, to permit the free circulation of air.

Most gages have the operating mechanism so attached to the case that a strain tending to warp the case will affect the accuracy of the indications. Therefore, the surface on which the gage is fastened should be flat, or conform to the surface of the back of the gage-case; it is also well not to tighten up too much on the screws or bolts used to hold the gage in place.

On account of the steam-gage being usually attached to the steam space (by law in Massachusetts), there is no tendency for scale produced by impurities in the feed water to form in these connections; but rust scale often forms in them, and due to their small size, they readily become stopped up. A number of very serious explosions have been caused by the stoppage of the connection to the steam-gage, and it is the safest to have all small piping used to connect the gage to the boiler or to the water-column piping, of brass; and if these connections are of any considerable length, their size should be increased to ⅜ or ½ in., instead of the ¼-in. size generally employed.

Since the location of a steam-gage is not very definitely fixed by its connection to the boiler, a location should be chosen that will make its indications easily seen from any part of the firing floor, and such that there is no likelihood of a mistake being made as to which boiler the gage is attached. A steam-gage should be tested periodically to determine its accuracy, and no power plant, no matter how small, should depend entirely on the indications of a single gage.

Blowoff Pipe and Connections

The blowoff connection is an important attachment. A

Fig. 7. Steam Gage Connection

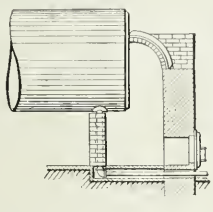

Fig. 8. Proper Blowoff

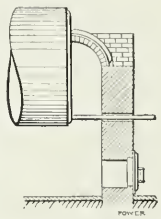

Fig. 9. Improper Connections

general idea is that the chief function of the blowoff connection is to remove scale and deposit from the boiler. A little reasoning will show the fallacy of presuming that this attachment can possibly accomplish such a purpose effectively.

If the reader has ever watched an open tank empty through a bottom connection, he will have noted that only the mud and dirt on the bottom immediately over the opening are removed at first, and that the main part of the discharged water is drawn from above the bottom, rather than from along the bottom. It is the same in blowing off a boiler; opening the blowoff for a short interval only removes the mud and scale immediately adjacent to the blowoff connection, or suspended in the water above it.

The principal function of the blowoff connection is to remove water from the boiler that has become concentrated or heavily charged with the various salts contained in the feed water, and thus permit the dilution of the water remaining in the boiler by the addition of fresh water from the feed supply. It is in this way that scale is prevented from forming in the boiler, by frequent use of the blowoff connection, and not by the actual removal of scale that has been formed. The blowoff connection is also necessary to permit the complete draining of the boiler for washing out or scaling, or for repair. The blowoff for a horizontal-tubular boiler should always be located in the bottom of the shell, about a foot in front of the rear head seam, as illustrated in Fig. 8. This location is preferred to any other, because it permits the complete drainage of the shell, and also that the blowoff pipe is more easily protected from the furnace heat at this point. It is not infrequent that a blowoff pipe is connected to the rear head as illustrated in Fig. 9, but this is poor practice. This connection does not permit the complete draining of the boiler, and this alone is sufficient to absolutely condemn it.

The blowoff pipe is often arranged as illustrated in Fig. 10, but this is not usually a satisfactory arrangement. If an elbow is used, as shown, it is difficult to protect it from the heat, and a fitting is more liable to suffer from overheating in such a location than the pipe. This objection is partially overcome by using a piece of bent pipe in place of the elbow, but this requires that a pipe coupling be placed inside the setting wall, for, since the blowoff is fitted up after the boiler has been set, the bent pipe must be short enough to turn inside the setting, so as to permit its being screwed into the flange on the boiler shell. A horizontal section of blowoff pipe in the fire is more difficult to protect from the heat than a vertical section similarly located, and there is also the added difficulty that deposit is more liable to lodge in the heated portion of the pipe in this position, and make its protection from the heat more important.

The best arrangement for the blowoff pipe is illustrated in Fig. 8, where it is run directly from the shell to a point below the paving of the rear combustion chamber, and the horizontal portion run through a brick trough, the top of this trough being formed of loose bricks that may be readily removed for inspecting the condition of the pipe. The vertical portion of such a blowoff pipe should be protected from the direct impingement of the flame from the furnace, by a V-shaped pier of firebrick, placed immediately in front of the pipe. This arrangement is best, because it does not in any way interfere with the thorough examination of the pipe, and also affords ample protection from the heat. A protection that is very effective, but which does not permit a ready examination of the pipe, is obtained by slipping a piece of larger-sized pipe over the vertical section of the blowoff, as illustrated in Fig. 11. To render this form of protection fairly durable, it should be arranged so that a small quantity of air will be admitted to the bottom end and flow upward between the two pipes.

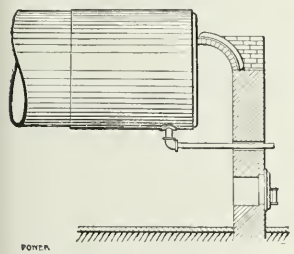

Fig. 10. Common Blowoff Connection

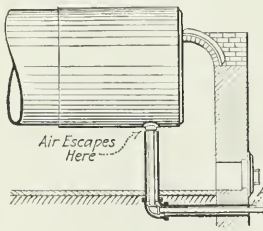

Fig. 11. A Practical Blowoff Pipe

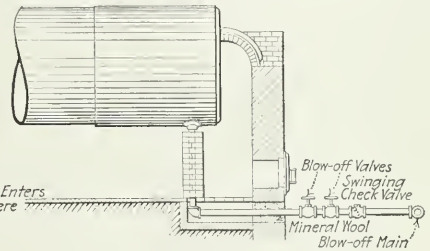

Fig. 12. Mineral Wool Packing around Pipe

Blow-off pipes are often protected by winding asbestos pe around them; which is fairly satisfactory, but it is ard to keep in place, especially if the protected portion the pipe is located so that it is liable to be struck with e cleaning tools. Asbestos rope is possibly the best, well as the most easily applied form of protection r use on connections such as shown in Figs. 9 and 10.

Where practical, the horizontal section of the blowoff pe should be a sufficient distance above the floor level, permit a suitable arrangement of the blowoff main d valves outside the setting walls. This requires, if the rrangement is to be as shown in Fig. 8, that the pave- ent in the combustion chamber be considerably above e boiler-room floor level. This arrangement also con- ibutes toward making it easy to remove the ashes from is portion of the setting, if ample room is available ehind the boiler setting. All pipe and fittings to the owoff connection should be extra heavy, regardless of e pressure carried, for this portion of the boiler equip- ent is liable to deteriorate very rapidly from various auses and the strains that may be brought upon it due operation of the blowoff valve or cock, are out of all roportion to the steam pressure carried.

It is an important matter to provide ample room round a blowoff connection, to prevent strains that may e produced by the pipe coming in contact with the set- ng walls, due to the expansion of the boiler or pipe. o prevent leakage of air where the pipe passes through e setting wall, the space left for expansion may be ghtly packed with mineral wool or some other heat- esisting material, as shown in Fig. 12, that will offer nly slight resistance to the free movement of the pipe. n the horizontal-tubular type of boiler, the blowoff pipe usually subjected to maximum movement at the point here it passes through the rear setting wall, due to the xpansion of the boiler, as well as the expansion of the ortion of the pipe contained in the setting, and it is also able to considerable movement at this point, due to the xpansion of the piping outside the setting, when in the ct of blowing down a boiler. The arrangement of the owoff piping outside the boiler setting where the pipes om a number of boilers are connected to a single blow- f main, is important, on account of the possibility of rains due to expansion.

The importance of this may be better appreciated when is considered that a change in temperature of 150 deg., ., in the piping, when blowing off boilers, is not nusual. This change in temperature on 100 ft. of pipe ould mean a change in length of about one and one- ghth inches. The length of pipe just considered would e about the amount required at the rear of a battery, ten 72-in. diameter boilers. If a main of this de- ription were held rigidly at one end, the branch con- ections to the boilers at the other end would have to e flexible enough to care for this amount of movement ithout unduly straining the fittings, or causing the pipe come in contact with the setting walls. It is usually est to have the blowoff main rest on the floor of the oiler room, if it is of concrete, and not fastened rigidly any point but allowed to move freely. If on account vibration, or to care for the thrust of some portion of e pipe that is extended beyond the boiler setting, it is ought advisable to anchor it, such anchorage is best pplied near the center of the battery of boilers. This divides the movement due to expansion in half and materially lessens the strains that may be brought on the fittings.

Blowoff Fittings

So much trouble has been experienced with the use of blowoff valves and cocks, that nearly every one connected with the operation of steam boilers and who has an inventive turn of mind, has tried a hand at solving the problem. The number of different kinds of valves and cocks used for the purpose is legion. A claim to some special virtue is usually made for each type of valve or cock; either some feature regarding its action in use or a peculiar form of construction that is supposed to render it immune to the usual forms of trouble experienced with this kind of apparatus.

The best arrangement for controlling a blowoff connection is to equip it with double valves or a valve and a cock of reliable make, using one to perform the actual act of opening the connection to blow down, and for stopping the flow; opening the other before and closing it after the first.

In this way, the seat of one valve is protected from wear, which is usually the result of the filing action pro-

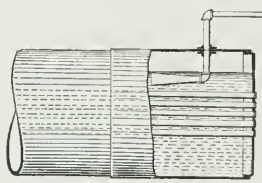

Fig. 13. Single-End Skimmer

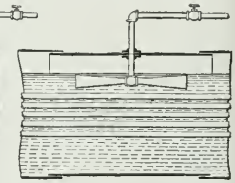

Fig. 14. Double-End Skimmer

duced by the escape of sand and other substances carried at high velocity across the seats, and especially through the restricted passages, produced at the instant of opening and closing the valves. Two valves used in the manner described require less attention than a single valve, because the protected one can be depended on to remain tight much longer than if one valve were used, and until this valve has begun to leak, no repair such as reseating, need be undertaken. Another feature that renders double valves desirable is that, when scale or other material blown from the boiler happens to lodge in one or the other so that it is rendered inoperative, as is frequently the case, the other valve is ready for use.

A globe valve is not suitable for use on a blowoff, because the tortuous passage through it is liable to produce stoppage by the lodgment of particles of scale; the cutting action produced by grit on the seat is also severe. In using a cock, or any quick-closing type of valve on a blowoff connection, serious strain may be produced in the pipe by water-hammer action in operating too quickly and on this account the size of pipe from the boiler to the valve or cock should be limited to 2½ in. Sizes below 1½ in. are liable to clog with scale or mud, so that the smallest boiler should be equipped with a blowoff of at least this size, if practicable. This leaves the small range in sizes, from 1½ to 2½ in., suitable for this purpose.

One of the objections to the use of a cock, especially of the common brass-plug cock style, is that the plug

heats up more rapidly than the body when blowing off, and is liable to seize fast, due to expansion, after being opened for a short time, and is thus prevented from closing. Engineers caught in such a predicament, with only one device on the blowoff connection, have attempted to loosen the plug by driving it up from the bottom. Such treatment is exceedingly dangerous as the fastening may give way, and the plug be blown out and the operator scalded. The Massachusetts rules very wisely provide that the plug on a cock must be held in place by a guard or gland, which is intended to prevent such an accident.

It is common practice to connect the blowoffs from two or more boilers into a common main pipe, to be led out of the boiler room to a suitable place for discharge. This arrangement has been responsible for scalding many boiler cleaners and repair men or others required to work inside idle boilers. In a plant containing many boilers a few are usually idle at all times for repairs or cleaning, and when a boiler is blown off into such a line, unless the blowoff valves on the idle boilers are closed, the pressure produced in the main blowoff pipe will force scalding water and steam back into the idle boilers. An accident of this kind is usually due to carelessness on the part of those working inside, in failing to see that the valves on the idle boilers were not closed, or else by someone tampering with the valves. There is one certain remedy that will prevent this class of accident; have the blowoff from each boiler separate and distinct, throughout its entire length. In the case of large batteries of boilers, and especially where the discharge point is at all remote from the boiler house, as is usually the case, this remedy will be expensive, and it is likely that the management of the plant will not consent to the necessary outlay. In such case, the writer would suggest a remedy, that while, as far as his experience goes, has never been used, would seem to be perfectly feasible. This is to equip the individual blowoff pipe from each boiler with a swinging-check valve, as illustrated in Fig. 12. This would prevent any sudden rush of steam or water back into a boiler from the blowoff main, and would not interfere to any serious degree with the outflow of water when blowing off, especially if the check valve was the next pipe size above that of the blowoff pipe from the boiler.

A point about the arrangement of blowoff piping, often overlooked in installation, that is liable to lead to a serious accident is seeing that the system of pipes drains thoroughly by gravity to the discharge point. A pipe that remains partly filled with water, which becomes cold between the times of operating the valves, is liable to cause severe water-hammer in the pipes during the act of blowing down. This action may break the fittings or the bonnets of the blowoff valves and probably scald the operator.

The blowoff connections on the various types of water-tube boilers are usually arranged at the lowest point, so as to drain the boiler as completely as possible, for the purpose of cleaning or repair. In some sections it is customary to have the blowoff pipe from the boiler of large size, 4 to 6 in. in diameter, and in the City of Chicago this construction is made compulsory by the municipal-boiler laws, the size being reduced at the blowoff valve. There seems to be no good reason for this kind of equipment, and there are objections. A large connection is placed on the boiler at a point which is exposed to high temperature, the large pipe renders the consequences of a rupture from any cause more serious and the danger of the pipe pulling apart at the threaded connections is increased.

Surface Blowoff

With feed waters containing salts, which tend to form light, foamy, floating deposits on the surface of the water, a surface blowoff is sometimes efficient in preventing foaming, a trouble that is liable to occur with this kind of feed water. The difficulty about the installation of this piece of apparatus is to get it to cover enough surface to be effective, and still not interfere too much with accessibility for the purpose of cleaning or repair. The usual arrangement is to have a flattened cone of thin sheet iron placed so that it will be central with the waterline. Fig. 13 shows the arrangement as usually used. Sometimes the funnel is made double-ended, as shown in Fig. 14, and is placed on the waterline at an equal distance from the two tube sheets, with the open ends pointing toward the front and rear heads of the boiler.

Power Development at the Panama-Pacific Exposition

A conspicuous feature of the Department of Machinery display at the Panama-Pacific International Exposition will be the latest methods of power development. The exposition is to be contemporaneous and not historical; therefore the evolution of the steam engine will play but a very small part.

The exhibits will contain a number of Diesel engines, operating upon California crude oils, which form such a large part of the resources of the state. The development of this type of motor has been somewhat checked in the past year by increasing prices of the fuel oil used. In the original conception of the Diesel engine it was anticipated that pulverized coal could be used as the fuel in the cylinder of the engine in the same manner as the liquid fuel is now used, but it was found that the residual ash from the solid fuel made this impossible. There is, however, being tried out in England a 100-hp. engine in which powdered coal fed by worm screw through tubular openings in the cylinder head is heated by the exhaust gases and the air supply for the engine drawn through the coal in such a way as to form producer gas, which is utilized in the engine as it would be in the ordinary gas engines. The range of fuel with which such an engine can be operated is much wider than that of the Diesel type and it is expected that among the exhibits at the exposition it may have its place and will represent practically the last word in power production.

The authorities have already been promised an exhibit of the Humphrey gas pump, which is a unique form of internal-combustion motor. In this pump the mixture of gaseous fuel and air contained in one end of a U-shaped tube is exploded by any of the usual methods of ignition, and the expansive force so produced forces the water out at the other end, where there is also a chamber within which the air is compressed by the water.

After the expansive force of the fuel charge is ex-

hausted the air compressed in this chamber sets up a return surge, which expels the burned gases and then swinging back with rhythmic impulse draws in a fresh charge of air and gas, as well as of water, which charge of air and fuel is compressed on the next return stroke and exploded when it reaches the point of highest compression, thus starting the cycle over again.

A pump of this type is being used today in London, having a pumping capacity of 50,000,000 gal. per day, and complete designs have been made for a German plant having 150,000,000 gal. capacity. This latter would be over four times the daily consumption of San Francisco.

This form of pump will probably find many applications other than that of pumping alone. It may be utilized for compressing air; and a proposition has been made in Germany to utilize it in power production by delivering the water which it discharges through a waterwheel directly connected to an electric generator. The combined efficiency thus obtained will be at least double that of the most improved form of steam plant.

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Conservation of Coal and Liquid Fuel

By Special Correspondent

SYNOPSIS—A résumé of the papers read at the eighty-third annual meeting of the British Association for the Advancement of Science, held at Birmingham, Eng., Sept. 10-17, 1913.

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The chief topic of practical interest to power-plant engineers that was dealt with at the recent Birmingham meeting of the British Association, was the more scientific use of solid, liquid and gaseous fuel, for the purpose of generating power or heat. A group of papers upon this most important subject was read in the chemistry and engineering sections of the association. Since the conditions in America today with regard to power generation from coal and oil, are similar to those existing in England, a résumé of the contents of these papers should prove of value.

After a general introduction, discussing the various prime movers for generating power and their defects, Professor Burstall in his paper on "Solid, Liquid and Gaseous Fuels" touched on the total remaining amounts of the various types of solid and liquid fuel available. The annual output of coal by the mines of the whole world was estimated to be about 1200 million tons—while that of crude oil was estimated at 50 million tons. Since it was doubtful if any large oil fields remained undiscovered, it followed that the supply of crude oil was totally inadequate to replace the solid fuel now used for power production. The artificial production of oil fuel ought, therefore, to be seriously taken in hand. Up to the present time coal has been gasified with the idea of producing the highest yield and volume of gas, but it is quite possible and practicable to alter the conditions of carbonization so as to obtain a high yield of fuel oils and other compounds of great value, including sulphate of ammonia. By the present methods of gasification, a modern gasworks will produce from every ton of coal between 11,500 and 12,500 cu.ft. of gas with a calorific value of 550 B.t.u. per cu.ft.: 10 gal. of tar; and 25 to 30 lb. of sulphate of ammonia.

The author thinks that the future of coal treatment in this and other countries will be in the decomposition of the fuel in closed retorts, under conditions which would make the yield of a standard illuminating gas the secondary consideration, and would elevate the yield of byproducts into the chief one. It has long been known that the quantity and quality of the tar is largely influenced by the temperature at which the fuel is carbonized, the lower the temperature the better being the yield and composition of the tar oils. If the gas and tar are withdrawn from the retort immediately they are evolved, many of the tar oils (after distillation) can be employed for power generation in internal-combustion engines. These tar oils will yield on distillation, benzol, light oils of the pentane and hexane series; middle oils such as crysilic acid, and finally heavy oils of the anthracene series.

The author then sketched out the details of a large scheme of this kind for treating coal at the pit's mouth; the carbonization units of this scheme being of 2000 tons fuel capacity per day. The tar and gas would be taken by pipe lines to suitable points for their further treatment, the tar being subjected to fractional distillation in continuous stills, automatically worked, to obtain the various light and middle oils from it, before sale of the residuum as a liquid fuel, or for road-making purposes.

Such a works would produce from 120,000 to 140,000 gal. of tar per day; the recovery of byproducts from this large amount of tar would be regulated according to the relative market price of the various oils obtained.

The gas generated from the carbonizers would not be purified from sulphur, but would be used in its crude state in large 2000-hp. gas engines for the generation of electricity. This would be generated at high voltage, and would be distributed over a wide area from the generating plant at the pit's mouth.

The exhaust gases from the gas engines would then be chemically treated, in conjunction with the liquor from the ammonia plant, and both these constituents—the nitrogen and sulphur—of the raw fuel would be recovered in the form of ammonium sulphate.

The author admitted that, at present, this scheme was somewhat visionary, but hoped to see it realized within a reasonable time.

Professor Armstrong opened the proceedings in the chemistry section on Monday morning, Sept. 15, by emphasizing the great importance of the fuel question, and the need for prompt action if the fuel resources were to be wisely used. In his opinion legislation was certainly required at the present date, to render illegal the use of raw coal for heating purposes, either in private houses or in works and factories, since only in this way could any reform of the present methods of heating be carried through in reasonable time.

All coal would then be subjected to destructive distillation before its use, and this distillation would be carried

at under the scientific conditions required to obtain a aximum yield of all the valuable byproducts.

Finally the methods of using gas for heating purposes ould also require to be reformed, and Professor Bone's ethod of obtaining remarkably high thermal efficiencies flameless combustion would doubtless be one that ould receive widely extended application in the near ture.

Dr. George Beilby, of Glasgow, contributed a paper on e "Low Temperature Carbonization of Coals" to the me section. After considering the advantages offered this method of treatment and discussing some of the uses of the failure of the "Coalite" system, the author ve an account of the practical progress made at the rks of the Cassel Cyanide Co. in Glasgow, with the sign of an improved retort and process for carrying out e low-temperature carbonization of solid fuel.

After numerous trials, extending over a period of four ars, an apparatus had been designed which would coke tons of coal per day, at a temperature between 750 d 840 deg. F. This apparatus was continuous in its stem of working and would convert cheap noncoking all coal, either into a fuel suitable for gas-producer rk, or into a smokeless fuel for domestic use, while at e same time enabling one to recover from the evolved ses all the valuable byproducts of the raw fuel. The ermal value of the gas obtained from the apparatus is high, namely, 850 B.t.u. per cu.ft.

In concluding his valuable paper, Doctor Beilby stated at the chief difficulties at present were due to the cak- g of the coal, and to the breaking down of the charge to coke no larger than the ordinary coke breeze. These re serious but not fatal defects. To render the coke ter treatment in the carbonizers fit for household use, was necessary to briquette it; for the gas-producer work e coke could be used exactly as it came from the car- nizing plant. The briquettes were manufactured by ing 7 per cent. of pitch as binding material, and they re sold in Glasgow at present for household use at the te of 20 shillings ($5) per ton. It was quite possible, wever (as the apparatus and process were improved) at this price might be lowered, and it was not given indicating the final value or price of the domestic fuel oduced by the process.

Finally, the author stated that the really significant ints in any successful process were covered by the onomic and engineering questions: Can an outlet be und for large amounts of this low-temperature coke? d can a satisfactory apparatus be devised? The ap- ratus must be constructed in fairly large units; it must automatic in working, and must operate with the oothness and regularity of the best types of automatic oking machinery, and with a minimum of manual labor of skilled supervision. The gases and vapors from e distillation must also be carefully preserved from ss or damage, either through leakage of the gas out- ard, or leakage of air inward. The necessary heat must so applied as to cause no deterioration of the material which the apparatus was constructed, and the heating the charge must be economic.

The author stated that he was not without hope that apparatus would be designed, which would tempt the thodox gas engineer to give low-temperature carboniza- n a serious trial on its merits.

Professor Bone, of London, followed Doctor Beilby with an account of the latest practice in the use of gaseous fuel, in the iron and steel industry. As Professor Bone is the patentee of the Boucourt or "flameless" combustion method of utilizing gas for heating purposes, his address was followed with much interest by a crowded audience. Discussing the relative costs of gas from various sources in the United Kingdom, he gave the following figures:

		Cost in cents per 1000 cu.ft.
1.	Coal gas, as made by an ordinary gasworks	24
2.	Water gas	8
3.	Producer gas, without ammonia recovery	3
4.	Producer gas, with ammonia recovery	2

The above represent the cost of production only. It is assumed in the case of Nos. 2, 3 and 4 that the producers work with a thermal efficiency of 70 to 75 per cent.; and the estimates are based on fuel costing $3.60 per ton, and coke realizing, when sold, $2.88 per ton.

With regard to the general question of heat utilization in iron and steel works, he predicted that at no very distant date, the need for a gas-producer plant in steel works would be nonexistent, and the furnaces would be heated, and the power generated, entirely by the waste gases from the blast furnaces and coke ovens. A modern blast furnace yields about 168,500 cu.ft. of gas per ton of iron produced. An output of 1000 tons of iron weekly represents, therefore, about 1,000,000 cu.ft. of gas per hour. This gas has a low calorific value; namely, 100 B.t.u. per cu.ft., and on this account after cleaning from dust, it forms an ideal gas for power-generation purposes.

The excess of blast-furnace gas not required for heating purposes, is now being employed extensively in modern iron and steel works for power generation, and at Seraing, in Belgium, where the greatest developments have occurred in this application of the waste gases, a 6500-hp. gas engine is now being erected as an addition to the existing generating plant. At this large works, the surplus gas from the blast furnaces is capable of generating 38,500 hp. continuously, at an efficiency of 28 per cent.

As regards the use of blast-furnace gas for heating purposes, at Skinningrove, in Yorkshire, the gas is enriched by admixture with coke-oven gases until it tests 130 B.t.u. per cu.ft., and this mixed gas is then employed for heating the Talbot and other steel-producing furnaces.

W. H. Patterson, of Liverpool, contributed a short paper on "The Improvements of Combustion Due to Blending and Chemically Treating Fuels." Tests were made on a marine boiler with two fuels, one marked A the other B. The laboratory calorific tests of these fuels gave the following values: A, 6524 cal.; B, 7351 cal.; while practical boiler trials gave the following evaporation: A, 8.87 lb. of water; B, 10.56 lb. of water per lb. of fuel. The fuels were then mixed in definite proportions, and this mixed fuel on practical trial in the boiler gave a much higher efficiency than the average of the above figures (9.71 lb.), the evaporative duty being nearly as high as that of fuel B alone.

Another remarkable effect was obtained by treating coal, while in a moist state, with chlorine gas. Not only was the heat efficiency increased and the ash diminished by this treatment, but the physical features of the coal appeared to undergo modification, and a bituminous coal

gained in this way some of the characteristics of a smokeless semi-anthracite fuel.

Papers upon "The Manufacture of Coal Gas," by Dr. H. G. Colman; by J. H. Yates on "Improvements in Gas Fires," by Dr. R. Lessing on "Smokeless Fuels and Coal Oils," and by Dr. R. V. Wheeler on "The Composition of Coal." were also contributed to this session. The most interesting statement contained in these four papers was that of Doctor Colman—that high-pressure coal gas (under 12 in. water pressure) was now being supplied through special mains in Sheffield and Birmingham for metallurgical purposes, and that a large number of manufacturers were employing this gas for melting and refining metals and alloys. The high-pressure gas in Birmingham was supplied at the same charge as ordinary coal gas, namely, at 32 to 36c. per 1000 cu.ft.

Doctor Wheeler gave details in his paper of a new method of separating raw coal into its two main classes of constituents, by aid of pyridine and chloroform. He also gave an account of the remarkable effects produced on photographic plates in the dark, by the resinous constituents of fuel. In the author's opinion this photographic method of examining a fuel might be used to guide one to a judgment concerning its caking and coking properties.

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A Remarkable Maintained Economy Test

By A. D. Skinner

Tests for maintained economy are so uncommon in this country that the results of the tests made on two double-eccentric, single-valve, tandem-compound Skinner engines, after 14 months' service, will no doubt be of interest. The causes that contributed to this unusual test were peculiar. The Universal Caster & Foundry Co., of Newark, N. J., were considering various types of engine, and the selection finally narrowed down to a single-cylinder multi-valve engine and the aforesaid make of compound engine.

Two engines of different capacities were to be purchased, and, while the guarantees made for the compound engines were naturally lower, the price was $1503 higher. The purchasers were willing to pay the additional price if they could be convinced by a practical demonstration that the compound engines would fulfill the guarantees made for them, not only while the engines were new, but after they had been in operation for at least one year and without any refitting of valves.

These conditions were agreed to and at the end of a year an economy test, conducted in accordance with the American Society of Mechanical Engineers' code for steam-engine trials, was to be made on both engines, and under the direction of a consulting engineer appointed by the purchasers.

Both engines were allowed to run for 14 months, instead of 12, for the reason that it was not convenient for either the purchasers or the engine builders to make a test after the engines had been in operation the stated period, and in the meantime the valves had not been tampered with or adjusted. F. H. Ogden, a consulting engineer, of Newark, represented the purchasers, who also had other representatives present to check the results.

Inasmuch as it was necessary to conduct the test by weighing the water before it was fed to the boilers, usual care was taken to insure its accuracy. A boiler and line-leakage test was made one month before the test of the engines, and a second leakage test was conducted on the same day on which the engine tests were made, the results of both leakage tests being almost identical. The water weights and levels in the boilers were checked during the engine tests at the end of each hour, and showed almost constant consumption, thereby verifying the final results. Water was fed to the boilers through injectors, the steam supply for which came from the boilers themselves. The water was weighed in barrels on scales which had been previously tested for correctness. The load was obtained by a water rheostat.

Two sets of indicator diagrams were taken, and the indicated horsepower was determined both by planimeter and by ordinate readings, and the planimeter readings being the smaller were accordingly selected by the purchasers' engineer. The indicator springs were removed by the purchasers' engineer immediately after the test and were calibrated by the indicator manufacturers, the Pratt Institute and the Stevens Institute of Technology, all calibrations agreeing.

After the tests the valves of both engines were tested for steam tightness by placing the valves on center, removing the indicator piping and opening the throttle to full boiler pressure. Neither engine showed any valve leakage.

As far as published records go, the results of these two tests establish a record for noncondensing steam engines of this type, operating under saturated steam conditions. The results are all the more noteworthy on account of the fact that the engines had been in operation for 14 months, without refitting of valves.

RESULTS OF TESTS

Date of trials	Oct. 6, 191	
Type of engines	Tandem compound automatic noncondensin	
Class of engines	Direct connected to alternator	
Rated power, indicated horsepower	320	384–40
Type of valve	Skinner steam tigh	
Dimensions	15½x25½x20	16½x28x20
Diameter of piston rods, in	2 7/16 & 3½	2 7/16 & 3
Duration of tests, hr	4	
Length of time engines were running at normal speed, hr.	6	
Total water fed to boilers, lb	23,355	23,18
Total water fed per hour, lb	5,838 75	7,728 3
Loss of steam and water per hour, due to drips, lb	87.25	97.0
Loss of steam and water per hour, due to leakage, lb.	659.00	659.0
Moisture in steam near throttle by throttling calorimeter, per cent	1.72	1.4
Net dry steam consumed per hour (equals water fed, less drips, leakage and moisture), lb	5,004 91	6,872.6
Steam at throttle, by gage, lb	132.56	131.2
Back pressure at mid-stroke above atmosphere, lb. per sq.in	1.00	0.9
Revolutions per minute	202	200
Average indicated horsepower:		
High-pressure cylinder	147.26	209.7
Low-pressure cylinder	130.30	178.2
Total	277.56	387.9
Approximate load	¾	Ful
Water as fed per i.hp.-hr., lb	21.04	19.9
Net dry steam consumed per i.hp.-hr. (equals water as fed less drips, leakage and moisture, lb	18.13	17.81

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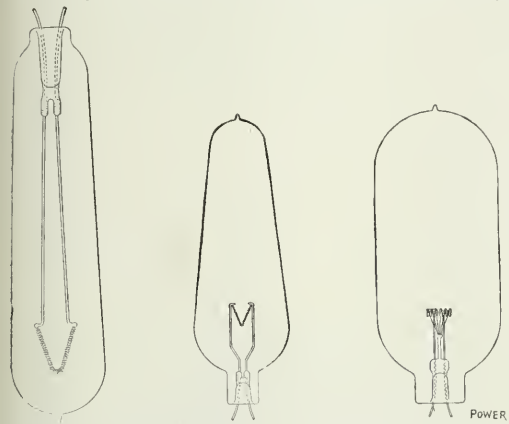
Peat Production Small—While the United States is the richest country in the world in the deposits of peat, little active work is done in mining or digging it. So far as is known very few of the peat-fuel plants established have gone beyond the experimental stage and many of them have never been equipped with essential machinery. Reports from all known peat-fuel plants in the United States, according to an advance chapter from "Mineral Resources, 1912," on the production of peat in 1912, by Charles A. Davis, show that with one exception they were idle during the summer of 1912. The output of peat fuel was reported as about 1300 tons, valued at $4550. All this peat was sold. A copy of the report on peat may be obtained free on application to the Director, U. S. Geological Survey, Washington, D. C.

ELECTRICAL DEPARTMENT

The Half-Watt Tungsten Lamp*

The first carbon-filament incandescent lamps consumed 5 to 6 watts per candlepower, but were gradually improved to about 3.1 watts. During the past few years this has been further decreased by the use of the metallized filament to 2.5 watts per candlepower. Moreover, since the introduction of the metallized-carbon filament progress with other types has been comparatively rapid and at the present time the most efficient incandescent lamp in commercial use is the tungsten, utilizing from 1 to 1¼ watts per candlepower in the ordinary sizes.

Notwithstanding this improvement the luminous efficiency of the ordinary tungsten lamp is not more than 6 to 10 per cent. If the maximum theoretical efficiency



HIGH-EFFICIENCY NITROGEN-FILLED LAMPS FOR LOW-VOLTAGE CIRCUITS

NITROGEN-FILLED LAMP FOR 110-VOLT CIRCUIT

were attained the consumption should not be more than 0.1 watt per candlepower.

It has long been known that ordinary tungsten lamps can be run at voltages much higher than rated and in this way extremely high efficiencies can be obtained, but the life of the lamps under these conditions is very short.

In ordinary practice the useful life of a lamp is considered to be the time which the lamp burns before its candlepower has fallen to 80 per cent. of its original value, or until the filament breaks, in case this occurs while the candlepower is still above 80 per cent.

The causes which made it necessary to operate tungsten lamps at such relatively low efficiencies were little understood at first and led to a series of exhaustive investigations at the laboratories of the General Electric Co.

The lamps were observed, ordinarily, to fail in one of two ways: either by breakage of the filament or by blackening of the bulb. The former difficulty was largely overcome by employing ductile tungsten and by improved methods of mounting the wire, but the blackening of the bulb continued to baffle the investigators.

At first this blackening was thought to be due to the presence of residual gases. These were determined, but experiments showed water vapor to be the only one which produces perceptible blackening of the bulb. In this case the process is cyclic; that is, the water vapor oxidizes and deposits on the bulb, where it is reduced by the free hydrogen, forming water vapor and leaving metallic tungsten.

Attempts to materially improve the life of the lamps by the more complete removal of water vapor resulted in failure, and it was concluded that, although water vapor is usually one of the principal causes of short life in poorly exhausted lamps, it is not the cause of blackening in well exhausted lamps. The real cause of blackening in well made lamps was finally proved to be due to evaporation of the filament.

It, therefore, follows that to improve the efficiency of tungsten lamps, either the rate of evaporation of the filament must be reduced or the evaporated tungsten must be prevented from blackening the bulb.

This result has been accomplished by the introduction of nitrogen into the bulb under atmospheric pressure and by changing the location of the deposit by means of convection currents so that the bulb opposite the filament does not darken. By making use of these principles the General Electric Co. has been able to construct practical tungsten lamps which have burned over 2000 hours at an average efficiency of less than 0.5 watt per candlepower. At the present stage of the development, however, it has been possible to attain these results only in large-sized lamps—over 1000 cp., as will be explained.

It was found that a much higher efficiency could be obtained when using large filaments than with those of small diameter, due to the relatively greater heat loss by convection from the small wires. Moreover, the life of the filament is determined largely by the loss of tungsten through evaporation and has been found to be dependent on the relative decrease in diameter caused by this evaporation.

If the rate of evaporation per unit area from large and small wires were the same, the lives of various filaments run at a given temperature would be approximately proportional to their diameters. However, as the evaporation of tungsten in nitrogen is largely a diffusion process, it probably obeys laws similar to those of conduction or convection of heat from a wire; that is, for wires of small diameter the actual amount of tungsten evaporated would be nearly independent of the size of the wire. The rate of evaporation per unit area would thus be approximately inversely proportional to the diameter. The relative lives of very small wires in nitrogen are therefore nearly proportional to the squares of their diameters.

*Abstracted from a paper by Irving Langmuir and J. A. Orange, read before the American Institute of Electrical Engineers, at New York, Oct 10, 1913.

However, it is not desirable to use filaments of very large diameters if similar results can be obtained with smaller ones, as the current increases as the three-halves power of the diameter of the filament. Hence, unless very low voltages are used, the power consumed by the larger wires is so great that only very high candlepower lamps can be made. Therefore, it is of vital importance to increase the effective diameter of the filament without decreasing its resistance. The most satisfactory method of accomplishing this is to wind the filament into the form of a tightly-coiled helix of as large a diameter as practicable. It has been found that the use of a helically wound filament increases the life of the lamp many times beyond that which would be obtained with a straight filament running at the same efficiency. This is especially true of the smaller sizes of wires.

In ordinary lamps about 20 per cent. of the energy radiated from the filament is intercepted by the glass and causes heating of the bulb. In the nitrogen lamp, besides this radiated heat there is additional heat carried to the bulb by convection—an amount varying with the type of lamp and ranging from 6 to 40 per cent. of the total input. The convection currents carrying this relatively large amount of heat travel vertically upward from the filament and strike a small area of the bulb, which thus tends to become greatly overheated. Unless special precautions are taken, this overheating will cause the liberation of enough water vapor to attack the filament and blacken the bulb. It is therefore desirable, if small bulbs are to be used, that the filament be mounted in the lower part. By special designs of bulbs satisfactory lamps have been made in which, for the same volume, nitrogen lamps give from five to ten times the candlepower of evacuated lamps.

The principal limitation of the new type is that of current. There is no practical upper limit to the current, provided the voltage is not lowered to keep constant power consumption. With increasing current, larger and larger filaments are used and the efficiency that may be practically reached increases toward the limit of 0.2 watt per cp., which is fixed by the melting point of tungsten.

For the particular type of nitrogen-filled lamp which has at present been furthest developed, it may be said that a life of over 1500 hours is obtained at efficiencies better than 0.5 watt per candlepower only in large units taking over 10 amp. Lamps consuming 0.6 to 0.7 watt per candlepower have been made, taking at least 5 amp.

No serious difficulty has been met in making high-voltage lamps. In nitrogen at atmospheric pressure there is no tendency toward arcing, even at 250 volts. Many lamps taking 6 or 7 amp. at 110 volts have been made and run at 0.6 to 0.7 watt per candlepower with a life of 1000 hours.

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Waterwheel Generators

Waterwheel generators are being built to conform with the rapid development of hydraulic power in various combinations of capacity and speed range. The following deals with the practice of one large company—the Westinghouse Electric & Manufacturing Co.—in this line.

Horizontal Type

The standard horizontal unit is of the two-bearing coupled-type construction; that is, the generator includes the shaft, two bearings, and a bedplate usually designed to allow for sliding the stator to one side in case ready access to either the stationary or rotating winding is desired: see Fig. 1.

The stationary frame is a rigid iron casting, into which soft steel laminations are dovetailed and securely fastened. Form-wound, interchangeable armature coils fit into parallel open slots punched in these laminations, and these coils are held firmly in place by fiber wedges. The coils are insulated and impregnated with fabrics and high-insulating compounds.

No single type of construction will meet the varied requirements in rotor design, therefore, several well tested methods are employed. When comparatively low peripheral speeds are encountered a cast-iron spider with bolted-on, or dovetailed poles, is usually employed. For higher speeds cast-steel or steel-plate construction may be used. In the case of very large relatively high-speed machines, the difficulty of securing perfect castings may lead to the well proved laminated rim structure, which is illustrated in Fig. 2.

All the field poles are made of thin steel laminations riveted together with overhanging pole tips provided to support the field windings.

The field coils are of heavy copper strap wound on edge and insulated in such a way that each individual turn is exposed to the ventilating air. The coil is fastened between the rotating spider and the tips of the field poles by heavy coil supports.

Vertical Type

Standard practice recommends that the generator be fitted with two guide bearings which are supported by brackets fastened to the stator frame, also, a bedplate or pad on which the stationary part rests.

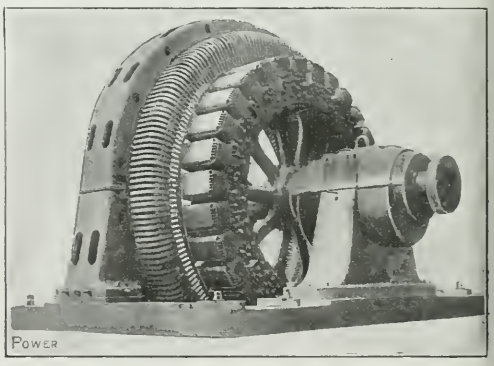


Fig. 1. Generator with Stator Slid Endwise to Permit Access to Rotor

The roller, or thrust bearing, which supports the weight of the revolving part may be mounted on top of the generator frame, between the generator and turbine, or underneath the turbine. In case it is mounted on top of the generator frame, this frame must be heavier and more expensive than where it has only to support the stator punchings, winding and guide bearings. Wherever placed, this bearing usually supports not only the rotor of the generator, but also the turbine runner, and in addition takes care of any unbalanced water thrust.

A rigid cast-iron frame into which soft steel laminations are securely dovetailed, forms the basis of the stator. Form-wound, interchangeable armature coils are held in open slots by means of fiber wedges. The coils are vacuum dried and impregnated before the outside insulation is applied. This outside insulation consists of wrappings of paper and mica on the straight parts of the coils which lie in the slots, and servings of treated cloth over

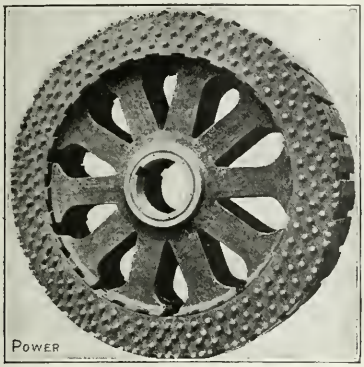


FIG. 2. LAMINATED-RIM ROTOR WITHOUT FIELD POLES

the V-shaped coil ends. After the outside insulation is applied the coils are treated with an insulating varnish which renders them moisture- and oil-proof. An insulating cell is provided in each armature slot to prevent abrasion of the coil and a fiber wedge holds the coils and cell firmly in position.

There are several designs of rotors, each especially adapted to the requirements for which it is used. Comparatively low peripheral speeds may permit the use of a cast-iron spider with either bolted-on or dovetailed poles. A higher speed generator may demand an entirely different construction. For such work cast-steel or rolled-steel plates are often employed. In case of very large machines, it may be difficult to obtain perfect castings, and here the well proved laminated-rim type of construction may be employed.

Field coils are ordinarily wound with heavy copper strap on edge and insulated between turns with asbestos. This construction is well adapted to give perfect radiating qualities and because of the heavy strap used is practically indestructible. The coils are securely fastened between the rotating spider and the projecting tips of the field poles by heavy coil supports.

Power-House Protection

The committee on power generation of the American Electric Railway Engineering Association recommends the following arrangements to protect power plants from shutdowns.

1. In all central stations, sufficient reactance should be provided in the generator circuit (either inherent in the generator or including external reactance) to limit the short-circuit current to a value which the apparatus to be protected can safely withstand.

2. In stations of large capacity or where excessive voltage disturbances at the busbars occur, reactances should be installed in the feeder circuits on the line side of the oil switches and in special cases between busbar sections.

3. In all outgoing feeder circuits, overload relays of suitable time characteristics should be installed.

(a) Instantaneous, on simple load distribution lines but normally used.

(b) Inverse time element, on overhead or underground transmission lines.

(c) Definite time element, in special cases on lines where conditions may demand the maintenance of power supply at all hazards.

(d) Reverse energy or current, on important tie lines and in switching or substations.

4. Install reverse energy or current relays on generator oil switches, or preferably on large generators use an adaptation of the Merts-Price system.

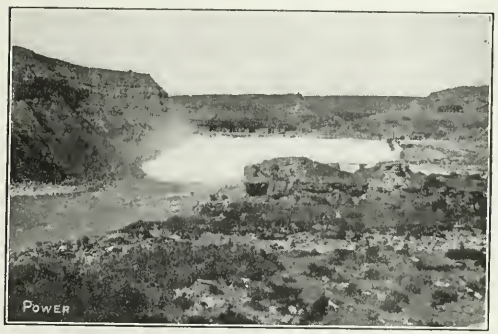
5. Use proper lightning-arrester equipment in all outgoing overhead feeders and in addition thereto, in special cases, directly on the bus.

6. Use mechanical or electrical interlocks to prevent improper switching.

7. Grounded neutral, preferably with resistance, may be employed to advantage, especially in connection with underground lines subject to frequent high-voltage surges.

Large Hydro-Electric Development in Montana

A large hydro-electric development is under way at the Great Falls of the Missouri, about 12 miles below the city



SITE OF GREAT FALLS DEVELOPMENT ON THE MISSOURI RIVER

of Great Falls, Mont. The power house when completed will contain six units, each of 15,000 hp., or a total of 90,000 hp. at a maximum head of 153 ft.

Generator for Use with Diesel Engines—Because of the nonuniform turning moment of an internal-combustion engine, necessitating a big flywheel effect, says "The Engineer," of London, the Oerlikon Co. has recently developed a new form of alternator for coupling to Diesel engines. It is built on the "outer pole" principle, that is, instead of the field magnets revolving inside the armature they revolve outside of it. Hence, for a given rim weight the flywheel effect is greater, in direct proportion to the squares of the diameters of the wheels, than that of the ordinary type of flywheel alternator.

HEATING AND VENTILATION

Sizing Pipe for Gravity Hot-Water Heating

The accompanying chart has been used with success by M. S. Cooley in determining the size of pipe for gravity hot-water heating systems. All of the variables appear in the chart, and the result, that is, the size of pipe, may be read directly. No computations are necessary. The derivation of this chart, which is plotted on logarithmic paper, and the method of using it, was made the subject of a paper read before the American Society of Heating and Ventilating Engineers at Buffalo. Passing over the derivation, the instructions for the use of the chart, as given by the author, follow:

One-Pipe System—Main in Basement

Radiator tappings, branches and risers: First ascertain the distance from the bottom of the flow main to the top of the radiator. Find this number at the base of the table and follow vertically to the intersection of the line inclined toward the right near the top of the table corresponding to the difference of temperature desired between flow and return connections to the radiator. Now follow the horizontal line passing nearest to this intersection toward the left until it intersects the dotted line inclined toward the right, and corresponding to the length of connections from the main to the radiator and back plus:

For each long-turn elbow or gate-valve, 5 ft.

For each short-turn elbow or angle-valve, 10 ft.

For each globe valve, 20 ft.

Now follow the vertical line, passing nearest to this intersection to its intersection with the horizontal line opposite the figure in the left-hand margin corresponding to the amount of radiation to be supplied, and the solid diagonal line inclined toward the right that passes above this intersection is the size of pipe required.

Example: Elevation, 6 ft.; temperature difference, 15 deg.; equivalent length, 50 ft.; radiation, 100 sq.ft. What size of pipe is required?

Follow the line from 6 at the base of the table to the intersection with the diagonal 15 deg. They intersect on horizontal line 2800; then follow line 2800 to intersection with dotted diagonal 50. From this intersection drop down to the horizontal line 100. The solid diagonal inclined toward the right above this intersection is 2 in.; therefore a 2-in. pipe will be required.

There is still to determine the head necessary to produce velocity. To obtain this find the diagonal line inclined toward the left passing nearest to the intersection of diagonal 2 and horizontal 100. This is 10, the constant for velocity head. Follow horizontally from the figure in the right margin near the bottom corresponding to this constant to its intersection with the lower diagonal 15 deg., and the head to produce this velocity is found in the lower margin. In this case it is 0.14 ft. This must be added to the friction head. In nearly all gravity work this velocity head is so small it may be neglected.

If it is desired to know the pressure in ounces per square inch equivalent to this head and temperature difference, follow the vertical 6 at the bottom of the chart to its intersection with the broken diagonal 15 deg., near the center of the table. Then follow the horizontal line to the right margin, where the pressure in ounces per square inch is found to be 0.2.

To ascertain the size of main, use the distance of the flow main at its lowest point to the bottom of the boiler as elevation, and the length of the main from the boiler back to same plus allowance for elbows, valves, etc., as equivalent length. Use a drop greater than that assumed through the radiator, and proceed as explained for the radiator.

Two-Pipe Reversed Circulation System

With the flow main in the basement, measure the total water travel from the boiler to the first-story radiator and back to the boiler, plus allowance for fitting as equivalent length. Use the distance from the bottom of the boiler to the top of the first-floor radiator as elevation. Ascertain sizes for the first floor. In a like manner ascertain sizes for the second floor, third floor etc. Now combine these sizes into a single pipe having equal carrying capacity in the following manner:

Note the figure on the left-hand margin, corresponding with the intersection of the diagonal for each pipe size. Take the sum and the pipe diagonal intersecting the margin at this sum is the size desired.

Example: Take two 1-in., three 1¼ in., and one 1½ in. pipes and find a pipe of equivalent carrying capacity.

Pipe, in.	Intersection		Number		
1	10	×	2	=	20
1¼	18	×	3	=	54
1½	29	×	1	=	29
					103
2½	110	×	1	=	size required

This neglects velocity head and is permissible for gravity work only. If the system is not laid out to give equal water travel to each radiator then ascertain the pipe size for each equivalent length and find the pipe of equivalent carrying capacity to the sum of pipes it serves.

Often there are two pipes to equalize, neither of which is fully loaded, and if they are equalized as in the foregoing too large a pipe will be obtained. In such cases and it is better to in all cases, run imaginary lines from the intersection by which the pipe size was determined parallel to the pipe-size diagonals to the margin and add the quantities so found to determine the equivalent pipe size.

Example: Elevation, 6 ft.; temperature difference, 15 deg.; length, 50 ft.; radiation, 100 sq. ft.; 2-in. pipe required. Elevation, 20 ft.; temperature difference, 15 deg.; length, 75 ft.; radiation, 100 sq. ft.; 1½-in. pipe required.

To combine a 1½-in. and a 2-in. pipe will require 29 + 62 = 91 = 2½-in. pipe.

Projecting the imaginary diagonals gives 23 + 39 = , so that a 2-in. pipe is sufficient.

By noting the intersection of the imaginary diagonal h the margin at each determination, as well as the e size, the combining can be quickly and correctly omplished by addition of these notations.

Overhead System—Single-Pipe Drops

Use one-half the vertical distance from the flow main the bottom of the boiler as the head. Make the drops the same size for the entire length and large enough to supply the total radiation on such drop. Use the temperature difference for the system divided by the number of stories heated as the temperature difference for each radiator in determining the size of radiator connections. Use the total water travel from the boiler back to same plus allowance for elbows, valves, etc., as equivalent length. If all drops do not have the same water travel determine the size of the main to supply each drop

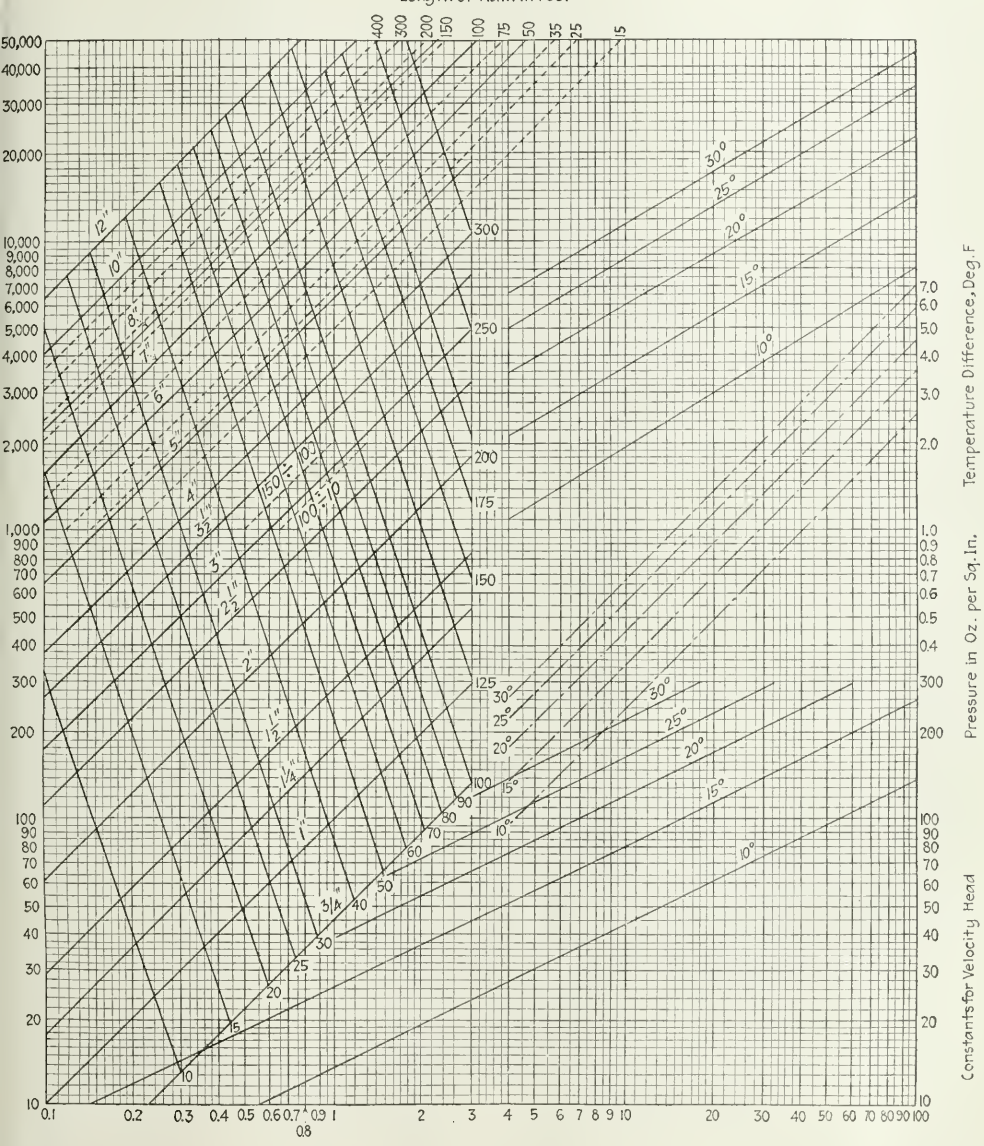


Chart for Sizing Gravity Hot-Water Heating Pipes

separately and combine, as herein directed, to determine the size of the main.

Overhead System—Double-Pipe Drops and Drop Insulated

Use the distance from the top of the radiator to the bottom of the boiler as the elevation for that radiator, and the total distance from the boiler to the radiator back to the boiler, plus allowance for elbows, etc., as the equivalent length. Ascertain the size of pipe for each story separately and combine into pipe of equivalent capacity. If drops do not have the same water travel determine the size of the main to supply each drop separately and combine to determine the size of the main.

In event the drops or risers in any system are exposed in the rooms there will be a certain amount of cooling in the risers, which is hard to determine. This will tend to aid circulation in an overhead system and retard circulation in a system with flow mains in the basement.

Air Washer vs. Centrifugal Collector on Dust-Collecting Systems

By James D. White

In the ordinary dust-collecting system a large amount of warm air is removed from the room containing the machines. The removal of this air is necessary, since for a material of given weight and character a definite number of cubic feet of air is required. During the months of the year when heat is not required the dust-removing system performs useful functions in addition to removing the dust by providing ventilation for the room. In the cold weather, however, this ventilation is provided at the expense of the heat required to raise the temperature of the air leaking into the room to the normal temperature maintained in the room. In certain cases buildings have a surplus amount of heat, due to manufacturing processes, in which case no additional expense would be incurred by the removal of the warm air from the building. As a usual thing this extra heat has to be provided at the expense of furnishing additional radiation in the building.

To form an opinion of the relative merits of the two systems, viz., air washer and centrifugal collector, the following calculations were made for a typical exhaust system from roll machines in a rubber factory.

As a basis of calculation it was assumed that the cost of the fan, piping, erection and freight would be the same for either system, also that the friction through the air washer would place the same resistance on the fan as the friction in the dust collector.

The apparatus was designed to remove the dust from 18 machines, each provided with a 7-in. connection. Assuming a suction of 2 in. of water at the hood and a coefficient of influx of 0.70, a velocity of 4000 ft. per min. would be required in the 7-in. connections.

The area of a 7-in. pipe is 38.5 sq.in., or 0.267 sq.ft., and

$$0.267 \times 4000 = 1068 \ cu.ft.$$

of air per min. per connection. Then

$$1068 \times 18 = 19{,}224 \ cu.ft. \ per \ min.$$

or 1,153,440 cu.ft. per hr. The heat required to raise 1,153,440 cu.ft. of air per hour from zero to 65 deg would be

$$\frac{1{,}153{,}440 \times 65}{55} = 1{,}363{,}156 \ B.t.u. \ per \ hr.$$

With an air washer in use this air could be recirculate at nearly a constant temperature. If a dust collecto were used the air and heat would be thrown away.

With steam at 5 lb. gage pressure it would require 1 supply the above loss in heat

$$\frac{1{,}363{,}156}{960} = 1420 \ lb.$$

of steam per hour. The transmission from pipe coils about 300 B.t.u. per sq.ft. of surface per hour. Then

$$\frac{1{,}363{,}156}{300} = 4544 \ sq.ft.$$

of pipe coil would be necessary to supply the heat was under maximum conditions.

Dividing the pounds of steam required per hour l 34.5 gives 41 hp. in boiler capacity necessary to supp steam to the coils. At $12 per horsepower installed t boilers would cost $492. A conservative price for pi coils is 25c. per sq.ft., which would amount to $11 for the total amount of extra radiation.

The cost of a dust collector for the above work is $30 The cost of a suitable air washer is $875. The air wash would be driven by a 3-hp. motor and assuming an ef ciency of 80 per cent. for the motor, an input of 3.75 h or 2.8 kw. would be required. If the plant were operat 10 hr. per day for 300 days per year, the cost of electrici for running the air-washer pump with current at 3 per kw.-hr. would be

$$300 \times 10 \times 0.03 \times 2.8 = \$252$$

A conservative figure for coal consumption is 65 of coal per year per square foot of direct radiation. T fuel consumption would, therefore, be:

$$\frac{4544 \times 65}{2000} = 147.6 \ tons \ per \ year$$

At $3 per ton the cost of extra fuel would be $1 The cost of using a collector, exclusive of the parts co mon to both, would be

Dust collector	$
Boiler	
Coils	1
Total	$1

Deducting the cost of the air washer, which is $87 leaves $1053, which is the balance in favor of an a washer. Interest, repairs and depreciation at 15 per ce would amount to $158.

The excess cost per year of the system using a c lector would be:

Interest and depreciation	$
Fuel	
Total	$
Deduction for running pump	
Balance	$

This is the net saving per year in favor of the syst using an air washer.

With a suitable screen for straining the water rec culation can be employed, involving a small outlay water. Slightly greater expense for attendance may necessary with a system using an air washer over a s tem using a collector. This, however, would be a sm item. It would appear that a substantial profit can made by using the air washer.

EDITORIALS

Application of the Nitrogen-Filled Lamp

With the announcement of another important development in the field of electric lighting, namely, the half-watt tungsten lamp, the question arises as to what extent it will displace the less efficient types now in use.

At present there seems little likelihood that it will be applied to the smaller sizes, that is, forty watts and under, which constitute about seventy-five per cent. of the tungsten lamps now in use. In these sizes the life of the lamp is determined more often by breakage of the filament than by evaporation of the tungsten and consequent blackening of the bulb. Moreover, laboratory experiments indicate that with the smaller nitrogen-filled lamps, the additional heat losses due to conduction and convection more than offset the saving due to decreased evaporation of the filament. It is only where filaments of greater diameter are used that the reverse is true.

Being confined, then, for the present at least, to the large sizes, the field for the new lamp will probably be in street lighting, hall lighting, and, in fact, wherever units of high candlepower are required. Already a lamp with a specially wound filament of high light concentration has been devised for lantern use. Owing to the steadiness of the light it appears better adapted for this service than the arc and leaves the operator free to give his entire attention to the slides or film.

To what extent the new lamp will displace the arc lamp for street lighting would be difficult to predict. Being a close competitor it will undoubtedly put the arc-lamp manufacturers on their mettle and we may, therefore, expect further improvements in this type.

We understand that the General Electric Co. has found the argon-filled lamp even more efficient than the nitrogen-filled, and as soon as a comparatively inexpensive means of producing this element in large quantities is devised it contemplates putting these lamps on the market.

Boiler Explosions

Boiler explosions may not be more common than heretofore, but they are certainly more numerous than they need be. Many users of steam boilers do not know what an immense amount of energy is contained in even a small boiler and they therefore take risks and compel others to take risks that are frequently entirely needless. Further, the men who pay the bills are not usually around the boiler very much and the danger is even less real to them than it would be if they were where they could hear escaping steam and see the hot fire under the boiler. They, therefore, compel the man whose bread and butter depends on his ability to hold his job, to take the risk. Frequently he does not dare say very much because he would be likely to lose his position if he did.

There seems to be no single remedy that will eliminate this danger as completely as it can be eliminated. If all possible remedies could be coördinated, the best results would be obtained and the number of boiler accidents would be reduced.

Two instances may be related, one in which the boiler exploded and the other in which it did not explode though it certainly had more than ample provocation, which illustrate two more sides to the danger of boiler explosions.

A short time ago POWER told of a boiler explosion that was certainly preventable and of which the owner had ample warning. It was a portable boiler having an internal-flue furnace. The furnace had bagged and the boiler was taken to a shop for repairs, but the repairman refused to make them on account of the dangerous condition of the boiler. The owner, therefore, pushed the bagged sheet back into place while the metal was cold, after which the engineer became so convinced that the boiler was unsafe that he gave up his job. Some time afterward the boiler exploded.

On another page is related an experience quite the reverse where the owner took the boiler out of commission when warned of its dangerous condition and no explosion resulted. The remarkable feature is that the boiler—a very old one and badly abused—had not exploded long before the repairman was called in.

Both of these instances prove the need of laws compelling the inspection of steam boilers and the employment of competent licensed men to operate them.

Interest in Educational Work

Criticism of the report of the Educational Committee of the National Association of Stationary Engineers was invited in an editorial in the October number of the *National Engineer*. We take this occasion not to criticize but to offer friendly and well intentioned comment on the report.

The National Association of Stationary Engineers surpasses all others composed of operating power-plant engineers. The membership totals more than twenty-one thousand, and its chief aim, as stated in its preamble, is to give preference at all times to the education of engineers.

The Educational Committee and its Advisory Board planned and put forth some excellent educational schemes last year. The sets of prize questions, including two advanced and two elementary sets for which a total of five hundred and ten dollars was offered for the best twelve sets of answers, three of the prizes being offered for each set, were very good. The prizes, too, were substantial, ranging from twenty dollars for the lowest to seventy-five for the highest prize. But the committee reports that only a total of fifty-one members entered the contests. Out of over twenty-one thousand engineers, all of whom would be benefited by competing in such work, only fifty-one responded—twenty-four one-hundredths of one per cent. of the membership!

The committee also reported that of the three hundred and forty or more associations, only three entered the contest for the four prizes offered for meritorious educational work, although the contest was advertised twice. There is no excuse for this wholesale indifference to the opportunities for power-plant education offered by the committee.

Surely there never was a time when power-plant engineers needed to devote themselves more closely to engineering education than the present. This is not solely because of the activities of the central stations, but because modern methods are forcing the engineer to realize that the dollar has the same value in the power end of the establishment that it has elsewhere. These conditions demand that engineers shall be better men technically than their fellows of yesterday. This knowledge must be acquired by most men through home study. Why, then, do so many members of engineering organizations remain indifferent to the advantages offered by the educational committees?

If it is because the men do not realize that conditions affecting them and their work are changing, then let efforts be directed toward making them realize that they are. If it is because those that show indifference show it willfully and refuse to be stimulated to action by proper educational methods, then it would seem that money appropriated for educational purposes is practically thrown away.

Membership in engineering educational bodies should denote progressiveness on the part of the members. Let each man manifest more of this spirit during the coming season than was shown during the season just passed.

⁂

Tied to the Plant

In a letter published on another page, the writer says: "I have known chief engineers who have not taken a vacation in from ten to fifteen years. In one instance the chief engineer had not been twelve blocks from his power house in six years." He wants to know the reason why.

If we were to hazard a guess it would be that the engineer believes he is the only man capable of running the plant, or else he has not surrounded himself with men who can work out of commonplace difficulties, which in nine cases out of ten is his own fault.

When an engineer has grown up with a steam plant and has seen all of the apparatus installed to the smallest pipe line, it is natural that he should feel he knows the layout better than any other man. He cannot bring himself to admit that an experienced engineer, in a few months, can so familiarize himself with the operating conditions that the chief's presence is not necessary to keep things moving.

When a chief engineer reaches the stage where he feels the plant cannot run without him he is not only deluding himself, but is not giving his assistants credit for much intelligence. It is easy to get into this way of thinking, but it is seldom justifiable. Every man has his own way of doing a thing. Because it is not the way the chief would do it does not necessarily mean that it is not an economical or workmanlike way. Every chief should give his men the right to think for themselves and do their work in their own way, so long as the desired results are obtained.

One chief engineer of a large central station stated that he lived too near the plant for his own good or that of his men. Whenever anything went wrong, someone would rush to his house, regardless of the time of night, and get him down to the plant to help or advise them, when, had he lived at a distance, the men would have got out of their trouble alone. A chief engineer should train his men to act for themselves and so long as they are doing the right thing, let them alone.

If a child were always carried it would never learn to walk. Just so with the engineer. Give him a free hand and there will be no reason why the chief cannot take a vacation or go any number of blocks from his plant.

Another reason for keeping close to the plant, perhaps more weighty with some chiefs, is the fear that their assistants will get their jobs. A man who knows his business need have no such fear; if he does not know his business, a change will eventually occur anyway. Further, a chief who labors under such misgivings cannot do justice to either himself or to his men. Suspicion will be directed to every movement, which will be detected by the men and unfriendly feelings will develop.

Every steam plant requires a chief engineer. His position is to direct, not act as emergency repair man. If his assistants are given to understand they are to get out of their own troubles, it will not be long before they will stop calling the chief every time a water glass breaks. Confidence in themselves will make them better engineers and capable of running the plant under ordinary conditions. The chief can then take his vacation and go as far as he likes.

⁂

Among many engineers there arises discussion as to the incidents surrounding the origination of the term horsepower as applied to the steam engine. The following quotation from "Farey on the Steam Engine," published in 1827, will be welcomed by many. Mr. Farey was a personal friend of Mr. Watt and lived during the time that the steam engine was being developed from a machine utilizing the pressure of the atmosphere on the piston to an engine using steam above atmospheric pressure and expansively in one or more cylinders.

> The machinery in the great breweries and distilleries in London was then moved by the strength of horses, and the proprietors of those establishments, who were first to require Mr. Watt's engines, always inquired what number of horses an intended engine would be equal to.
>
> In consequence, Mr. Watt made some experiments on the strong horses employed by the brewers in London, and found that a horse of that kind, walking at the rate of 2½ miles per hour, could draw 150 lb. avoirdupois by means of a rope passing over a pulley, so as to raise up that weight, with a vertical motion, at the rate of 220 ft. per minute. This exertion of mechanical power is equal to 33,000 lb. (or 528 cu.ft.) of water raised vertically through a space of 1 ft. per minute, and he denominated it a horsepower, to serve for a measure of the power exerted by his steam engines.

This estimate is much beyond the capacity of the average strong horse. Smeaton and other early engineers estimated that 22,000 lb. per min. was more accurate.

⁂

The fireman who said, "Boss, what CO_2 percentage do you want today?" may have known his business, but the one who blew water to the sewer through the water-column drain because he was receiving a bonus based on capacity as indicated by the feed-water meter was not particularly dense.

READERS WITH SOMETHING TO SAY

Engineers' Wages

Referring to the question of engineers' wages, probably everyone concerned knows that the average operating engineer is paid less than an ordinary pipe fitter with the disadvantage that his time is hardly ever his own.

He never knows whether he will be able to get away on his day off or not. He is subject to call any hour of the night, if an oil cup stops up.

I have known chief engineers who have not taken a vacation in from 10 to 15 years. In one instance the chief engineer had not been twelve blocks from his power house in six years.

What makes a man do this? Not his salary, surely. It must be that he likes his profession, or is mentally deficient.

I am with a company which makes nearly all kinds of large power machinery. I visit a number of medium-sized and small plants each year. From what I see, it is a wonder that the central stations have not closed down more small plants than they have. A large percentage of them certainly have no right to exist under their present system of operation.

Take the case of the gas engine. The success or failure of a gas-engine installation depends 90 per cent. upon the operating crew. They should be on the job every minute, anticipating trouble, meeting it half way. A steam engine will run with the valve setting out, without oil for hours at a time, without serious immediate trouble. The gas engines demands constant attention, it either runs with economy or not at all. This is especially so in some cases of producer-gas engines.

Power machinery is usually sold under a year's guarantee. This has spoiled a lot of engineers. It is safe to say that gas-engine builders have more trouble about that one year's operation than the builders of steam prime movers. The operating engineer gets into the habit of putting his troubles up to the builder; he does not worry much about them. One chief engineer saw his plant only once a week for the year during which time the builders operated it. When the year expired, his company had to double the number of gas engines to get continuous service.

Repeatedly the builders' engineers travel hundreds of miles to make some slight adjustment which the operating man could do equally well if he were "on the job."

A company in the South bought three 300-kw. gas engines. The engines ran beautifully while the builder's engineers were in the plant, but a year later, after a series of troubles nearly all of which could be traced to lack of prompt attention, the company bought steam turbines of the same company who built the gas engines and shut the gas plant down.

The operating engineers must take a large share of the responsibility for the slow introduction of the gas engine to general use in this country. The gas engine is suitable for the medium-sized plant and engineers running them need not fear the central station. Their raise in wages will come out of the coal now thrown away.

J. R. BELKNAP.

New York City.

The Polar Planimeter on Circular Charts

Julian C. Smallwood, in the Aug. 19 issue of POWER, states that "the ordinary polar planimeter may be used to obtain approximately the average value of the quantity shown by a circular chart from a recording instrument," and proceeds to demonstrate this hypothesis by employing a pressure-recording chart on which has been

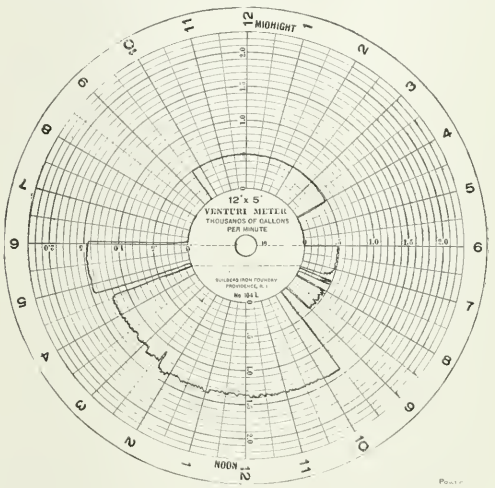


FIG. 1.

traced a continuous line showing an average variation in pressure of perhaps 20 lb. for a six-hour period. From the familiar formula,

$$Area = 3.14\ R^2$$

he obtains a value of 2.06 in. for the radius R which, when laid off on the chart, gives an average pressure of 97 lb. This checks, he states, with the value obtained by using a theoretically correct averaging instrument.

In order for the hypothesis to be of practical value we should know what the author means by the word "approximately." The meaning is apparently made clear in the closing sentence of the article which affirms that the error in the result with a polar planimeter on a circular chart, "except in extreme cases," is not greater than 2 per cent.

The writer does not agree in this conclusion with Mr. Smallwood. Generally speaking, the method used would be accurate enough for charts from pressure recorders

when the pressure is kept very uniform during the 24 hr. Should, however, a high steam pressure be maintained during the day and a low pressure during the night, as is often the case, the method in question would show an error much greater than 2 per cent., even though the pressure did not vary during each period.

There are now in use a great variety of recording instruments in engineering work where the rate or amount recorded often fluctuates widely from hour to hour. Without referring further to such charts, which might perhaps be called "extreme cases," let us consider an average record.

Fig. 1 is an exact reproduction of a circular chart from a 12-in. venturi meter in service at the pumping station of the East Providence Water Co., East Providence, R. I. The meter is on the discharge line of a centrifugal pump which is running for only a portion of the 24 hr. and is operated at different speeds as necessity requires.

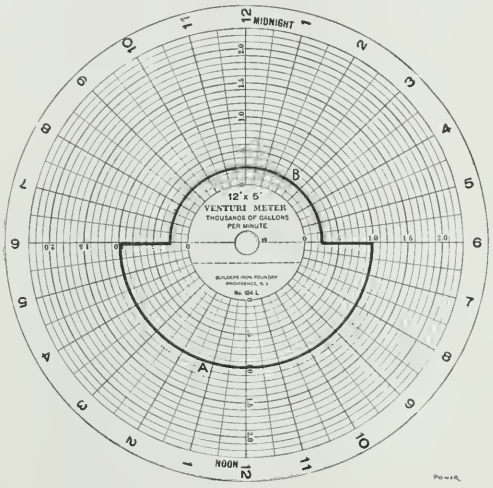


FIG. 2.

For instance, the chart discloses that at 9:30 p.m. the pump was started and discharged at a rate of 500 gal. per min. until 4 a.m., when it was shut down again. It is a simple matter to obtain the average rate during each 12-hr. period by totaling the half-hour rates and dividing by 24. This gives the following results: 6 a.m. to 6 p.m. average rate is 1000 gal. per min.; 6 p.m. to 6 a.m. average rate is 270 gal. per min.

In other words, the total pumpage obtained would be exactly the same had the pump discharged steadily at these average rates for the two 12-hr. periods named. A polar planimeter, if made to trace the shaded line, would show a total area equal to the area of the semicircle *A* plus the area of the semicircle *B*. On the actual chart this area equals 19.39 sq.in. Therefore, the average radius *R* equals

$$\sqrt{\frac{19.39}{3.14}} = 2.48 \; in.$$

corresponding to an average rate, when laid off from the center of the chart, of 680 gal. per min. But the average rate by the first method is

$$\frac{1000 + 270}{2} = 635 \; gal. \; per \; min.$$

and

$$\frac{680}{635} = 1.07$$

which shows that the polar planimeter is in error to the extent of 7 per cent. too great.

If the actual rate of discharge had been zero for the first 12 hr. and 2000 gal. per min. for the remaining 12 hr., the error by the polar planimeter method would have been 26 per cent. too great.

It seems evident, therefore, that the polar planimeter should be used with great caution on circular charts and that it is only of sufficient accuracy, even for practical purposes, when all of the autographic line lies in one narrowly confined portion of the chart. The safest method is to average by taking a large number of readings, depending upon the character of the record, or best of all to employ one of the new planimeters which have been devised especially for this purpose.

CHARLES G. RICHARDSON.

Providence, R. I.

Preventing Freezing of Air-Driven Pumps

Several years ago I visited a small stone quarry in which the largest engine was of about 150 hp. and operated by compressed air part of the time. The air supply came from the plant of a large company which used air for drills and other machinery, and had two 1200-hp. compressors. The two companies were about a mile apart. There was an 8-in. line from the compressor plant to the mill engine, hoisting engines, drills, etc., at the quarry. The pressure at the end of the line was about 120 lb. To prevent the air from freezing in the exhaust pipe of the engine, it was heated in a separately fired heater built like a separate-fired steam superheater. A large drip pocket was placed in the main on the cold-air side of the heater to drain out any entrained moisture that had separated from the air. The air was then passed through the heater where its temperature was raised to about 180 deg. F. The line to the mill engine was covered, but the line to the hoisting engines and drills was left bare. This gave practically no trouble from freezing in the exhaust ports. The heater was fired with coal, and did not require a great deal of it to keep the temperature up.

On what basis the small company purchased the air I do not know, but as the feed water at that plant was the worst I ever saw for forming scale, although it was as clear as glass, they found it cheaper or at least more desirable, to buy compressed air than to run the machinery by steam as the boilers were old, and not large enough to carry the full load. At times the 150-hp. mill engine was operated days by steam, and nights by air. In changing over from air to steam or *vice versa*, the engine was not shut down but the air and steam pipes were connected just above the throttle, and one was slowly opened and the other slowly closed. In changing from air to steam the cylinder cocks had to be left open for a few minutes until the cylinder became warm, as there was much condensation. This extreme change of

temperature must also have been very severe on the cylinder, but it was done for several years. The same grade of cylinder oil was used for air as for steam.

J. C. Hawkins.

Hyattsville, Md.

In a coal mine close to the plant where I am employed, compressed air is used to operate the water pumps in the pit, which is situated some 3000 ft. from the compressor.

At the end of the air line is a small receiver and the pumps in turn are connected to the receiver. By frequently blowing the water out of the receiver or by leaving the bleeder valve slightly open they get comparatively dry air and are not troubled with the pumps or the drilling machines freezing up.

The letter from E. R. Pearce, of Rochdale, Eng., caused me to look back over the June 17 issue in regard to the water disappearance in T. G. Thurston's sight-feed oil glass, and I do not think that Mr. Pearce has made the right diagnosis of the trouble.

While glycerin will keep oil from sticking to the glass while working, I do not think that it would help this trouble as it would very likely disappear as the water did.

From the statement of Mr. Thurston's letter the explanation to me seems to be this: He stated that the two oilers that were giving him the trouble were connected to the steam chest and subjected to a 25-in. vacuum after the steam was cut off, which very likely draws the water out of the sight-feed glass into the steam chest. He states that when he closes the valve between the engine and the sight-feed glass the trouble does not appear. This evidently shows that the engine is drawing the water out of the glass.

If he will connect the feed above the throttle valve he will get better lubrication and his trouble will disappear.

D. E. Aden.

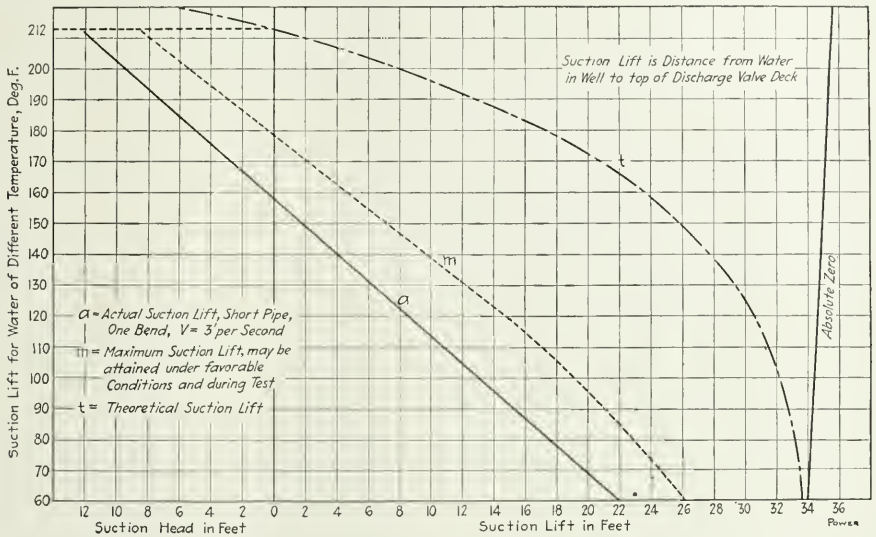
Wilburton, Okla.

Lifting Hot Water

The reply to F. D. S., in the Sept. 16 issue, was rather of a negative character and did not give him the desired information. He wanted to know the highest temperature at which water can be lifted by the suction of a feed pump to a height of 5 ft. and the reply gave him the theoretical temperature of 204.1 deg. F. and it was said that water at this temperature cannot be lifted 5 ft., stating the correct reasons why it could not.

The same condition prevails at any other temperature. Thus for a temperature of 60 deg. F. the theoretical suction lift is nearly 34 ft., yet we cannot safely lift water over 22 ft. This brings up the question: What limits the suction lift and why cannot this theoretical suction lift be approached more closely?

The reasons are manifold: Velocity head, entrance head, friction in pipe, losses in bends, losses through suction valves, inertia of water column, vapors from the water and air.



Theoretical, Maximum and Actual Suction Lifts for Various Temperatures

At the low velocities usually encountered in the suction pipe, the first few items can be shown to be insignificant. The velocity should not exceed 180 ft. per min., or 3 ft. per sec. For this we have:

Velocity head

$$hv = \frac{v^2}{2g} = 0.14 \text{ ft.}$$

Entrance head

$$he = \frac{hv}{2} = 0.07 \text{ ft.}$$

The friction in the pipe will also be small for the same reason and for a short pipe, usually:

$$f = hv = 0.14 \text{ ft.}$$

Losses in bends

$$\text{Each bend } b = \frac{hv}{2} = 0.07 \text{ ft.}$$

and for, say, three bends, 0.02 ft.

Losses through suction valves consist of friction which s insignificant on account of the low velocity and the hortness of the path, and the spring pressure which is sually

$\frac{1}{4}$ *lb. per sq.in.* = 0.6 *ft. water column*

These five items added together give a total of 1.15 ft., hich does not account for the loss of 12 ft.

The inertia or momentum of the water column is lamed by many for this condition and they proceed to lculate it for a single-acting pump without vacuum hamber, a type which does not exist. A duplex pump roduces a very steady flow of water in the suction pipe nd this is made still more uniform if a vacuum chamber e used at the pump and the same effect is attained by a rge vacuum chamber on a single double-acting pump. he effect of the inertia need not, therefore, be taken nto account.

The inertia of the water column is of great importance hen hot water is being handled but does not explain ne shortcoming on cold water.

Air remains as the only item to which we must look as ne principal reason. Water under atmospheric condiions contains about 5 per cent. of air in solution. This r expands in the suction pipe and enters the water cylnder in this expanded condition, cuts down the capacity nd causes shocks limiting the speed at which the pump an be operated safely.

Suppose we were to lift water 26 ft., which would give n absolute head of

$$34 - 26 = 8 \text{ ft.}$$

he air would then expand

$$\frac{34}{8} = 4.25 \text{ times}$$

nd would fill

$$4.25 \times 5 = 21.25 \text{ per cent.}$$

f the pump barrel. Fortunately, it is not so bad beause the water passes through the suction pipe so quickly hat all of the air has not time to liberate; otherwise e would not be able to lift water any height. This also ows why long suction pipes, where a greater chance is ven to the air to separate from the water, are such a etriment to satisfactory pumping.

In the diagram the line marked absolute zero gives the eight of a water column required to balance the atospheric pressure. This is measured from the zero ne marked *O*. This height increases with rising temerature. From this line the absolute pressure correonding to the temperature is deducted and thus the ne *t*, the line of theoretical suction lifts, is obtained. he line *a* is the actual lift attainable under ordinary nditions and is the maximum lift that might be atined during a test when everything is in perfect order. It will be noted that the line *a* approaches the theotical line at both ends and this is as it should be. At w temperatures the effect of the air is not so marked, ecause the air is not liberated so easily as at high temeratures, and if the water comes in under a head the fect of the air disappears likewise because it does not pand in the suction pipe but remains in a compressed ate.

This curve answers F. D. S.'s question. At 5 ft. suction lift we find a point 135 deg. F. at line *a* and nearly 0 deg. F. at line *M*.

F. F. NICKEL.

East Orange, N. J.

Leaky Piston

The diagrams herewith were taken from the cylinders of a compound marine engine 12 and 24⅛ by 15-in stroke and are of interest in showing the kind of diagrams which were obtained from an engine in which the leakage past the high-pressure piston was so bad that at times it was difficult to start the engine on account of being steam-bound.

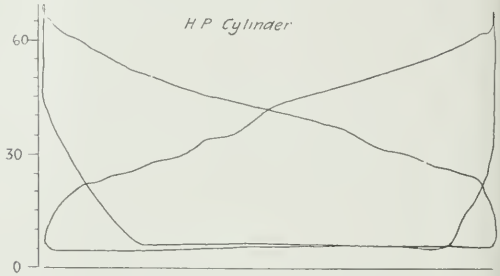


FIG. 1. DIAGRAMS FROM 12X15 HIGH-PRESSURE CYLINDER WITH LEAKY PISTON

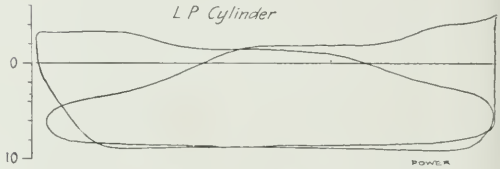


FIG. 2. DIAGRAMS FROM 24⅛X15 LOW-PRESSURE CYLINDER

G. C. C. BELLING.

Kinkiang, China.

Pipe Flange as Emergency Gland

I had the misfortune of breaking the gland on the steam end of a 10-ton refrigerating machine. I was alone on a night shift in charge of the boilers, generator and refrigeration system, so the repair had to be made in a hurry. I ran the machine with the gland held by one bolt until I could find a 2-in. pipe flange, which I slotted to pass over the piston rod, and placed it over the broken end of the gland. The flange required no drilling as the holes in it came in the right place for the studs in the stuffing-box.

F. E. WALCHLI.

Denver, Colo.

Wants Method of Cost Finding

I would like Henry D. Jackson, or some other reader of POWER, to give me methods for getting at the cost per kilowatt-hour in an isolated 200-kw., alternating-current, direct-connected plant, doing its own steam heating in winter. Wages $10 for 24 hr. Coal $4.50 per ton of 2240 lb.

ERNEST MILTON.

Buffalo, N. Y.

INQUIRIES OF GENERAL INTEREST

Height of Lift—If a vacuum gage attached to the top of an upright suction pipe from a well indicated 22 in. vacuum during pumping, what would be the distance from the gage down to the water in the well?

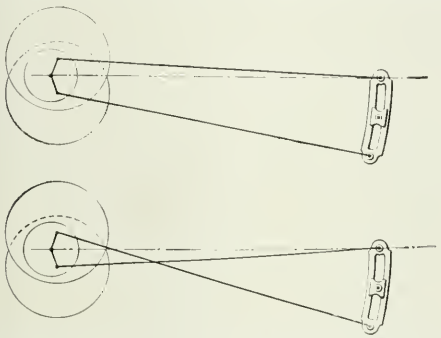
F. R. M.

If there were no friction and a tight suction pipe then 22-in. vacuum would indicate a distance of $\frac{22}{30}$ of 33.947 = 24.89 ft., but overcoming air leaks and friction due to an ordinary velocity of water in the suction pipe would reduce the figure to about 23 ft.

Link Motions—In a Stephenson link motion what are the advantages, one over the other, of open eccentric rods and crossed eccentric rods?

E. P.

The upper diagram herewith shows an open-rod link motion, the lower one a crossed-rod link motion. With open rods the lead increases and with crossed rods it decreases from full gear toward midgear. Other conditions being the same crossed rods are longer than open ones, thereby making



less variation in lead from full gear to midgear. With crossed rods, if a valve has no lap at midgear it would have lead for all other gears, whereas with open rods, if the valve has no lap at midgear it would have no lead at other gears. Hence, with crossed rods, the ports may be covered at midgear and still have lead at other gears; while, with open rods, to secure lead between midgear and full gear, the ports would have to be open at midgear, and with an open or leaky throttle, the cylinder would get steam, which under some conditions, as when engines are supposed to be standing still, is undesirable.

Collapsing Strength of Tubes—What formula will give the collapsing strength of an ordinary boiler tube? In which way is such a tube stronger, against inside or outside pressure?

J. E. M.

The formulas based upon the experiments on the collapsing strength of boiler tubes made by Prof. Reid T. Stewart for modern lap-welded bessemer steel tubes, for all lengths greater than six diameters, are as follows:

$$P = 1000\ (1 - 1 - 1600\ \frac{t^2}{d^2}) \quad \text{.....(A)}$$

$$P = 86{,}670\ \frac{t}{d} - 1386 \quad \text{.....(B)}$$

where

P = Collapsing pressure, lb. per sq.in.;
d = Outside diameter of tube, in.;
t = Thickness of wall, in.

Formula A is for values of P less than 581 lb., or for values of the thickness of the tube divided by diameter which yield a quotient less than 0.023, while formula B is for values greater than these. In applying these formulas, in practice, a suitable factor of safety must be applied. The resistance to internal pressure is about four times as great as the collapsing strength.

Starting a Turbine—How much time is required in starting a turbine and throwing it on the switchboard? What is the procedure in starting up a turbine?

R. A. C.

Full answers to both of the above questions may be found in the prize article on turbine running printed in the August 6, 1912, issue, page 176. Turbines with small clearances and large dummy pistons must be carefully warmed when first started. Those having large clearances and of the nozzle type such as the De Laval can be started very quickly. A 5000-kw. unit has been put under way in a minute and a half. The throttle should be opened only a trifle at first and a little more at a time. All drains should be left open until the turbine is nearly up to speed. While the turbine is warming up the auxiliary machinery can be started. The turbine should be speeded up slowly except while it passes the critical speed where the tendency to vibration is a maximum. With normal speed attained and a good vacuum established, the load should be applied gradually to keep water slugs from being carried over with a sudden inrush of steam.

Inches of Pressure—What is meant by pressure in "inches of water" or "inches of mercury"?

A. A. B.

Low pressures of gases, vapors and liquids are conveniently measured by and compared to the hydrostatic pressure exerted by the head or height of liquids of known density. Measurements of such pressures are usually determined by observing the difference in height of liquid columns required to balance the difference of pressure exerted on the surface of the liquid in the branches of a U-tube; or by direct measurement of height of a single column as in a barometer, where atmospheric pressure, acting on the surface of a liquid like mercury, balances a column of the liquid in a tube, the lower open end of which is in communication with the same kind of liquid in a cup or "well," while the upper end of the tube has a sealed space which is a vacuum.

The pressure per square inch for each inch of height of column of any liquid will be the same as the weight of one cubic inch of the liquid. A pressure of 1 in. of water at 62 deg. F. = 0.03609 lb., or 0.5774 oz. per sq.in. and of 1 in. of mercury at 62 deg. F. 0.491 lb. or 7.86 oz. per sq.in.

Hoisting-Engine Problem—What would be the horsepower of a pair of hoisting engines with cylinders 16 in. in diameter by 15 in. stroke, making 33 r.p.m., supplied with steam at 90 lb. gage and exhausting into the atmosphere? The engines are connected to a 5-ft. drum. What load could they lift?

J. E. C.

When running with full gear forward or backward, the mean effective pressure would be about 85 lb., making the horsepower

$$\frac{85 \times (16 \times 16 \times 0.7854) \times 1\frac{5}{12} \times 33 \times 4}{33{,}000} = 85.45 \text{ i.hp.}$$

With a pair of engines having cranks set at 90 deg., starting to lift a load, one crank might be on dead center, so that the starting power would depend on the force exerted by the steam on only one piston. The piston area being

$$16 \times 16 \times 0.7854 = 201.06 \text{ sq.in.,}$$

and steam pressure 90 lb. the force exerted on one piston would be

$$201.06 \times 90 = 18{,}095.4 \text{ lb.}$$

The drum being 60 in. in diameter and its radius 30 in., while the stroke of the engine is 15 in., and the crank radius 7½ in. then, without friction, one piston could start a load of

$$18{,}095.4 \times \frac{7\frac{1}{2}}{30} = 4523.8 \text{ lb.}$$

But as the net efficiency would be only about 70 per cent. the total load which the engine could be depended upon to start would be about

$$4523.8 \times 0.70 = 3166 \text{ lb.}$$

The lifting power will increase up to the point where both pistons are equally effective, and then the lifting power will be about 40 per cent. more, or about 4432 lb.

ENGINEERS' STUDY COURSE

Feed-Water Treatment

A cardinal requisite to high boiler efficiency and consequent low operating cost is a clean boiler both outside and in. The man who neglects to protect the outside of the heating surface from the accumulation of slag, soot, etc., and the inside from accumulation of scale, etc., simply because it is a bother to do so, is not living up to his opportunities.

The main sources of feed-water supply are wells, rivers, ponds, lakes, etc. The great primary sources of supply to these secondary sources are the oceans which cover about three-quarters of the earth's surface. This water contains so much impurities that it is unfit to drink or to use in a boiler until it is purified. The chief impurity is salt, the chemical name of which is sodium chloride and the chemical symbol is NaCl. The letter S could not be used in the symbol because S, you will remember, is the symbol for sulphur, so the abbreviation Na, of the Latin name *natrium,* is employed.

A gallon of sea water contains about 1.75 lb. of salt. To illustrate how difficult it would be to operate on sea water, it has been estimated that a 72-in. by 18-ft. tubular boiler (150 hp.), if it could be operated continuously at its rated capacity on sea water, would fill solid to the water line with salt in about 48 hr.

For stationary boiler plants, nature herself performs part of the purifying process. The heat of the sun causes ocean water to evaporate and rise in the atmosphere to form clouds. As salt does not vaporize at ordinary temperatures it remains behind, while only the pure water itself rises in the air. Changes in the atmospheric temperature and pressure cause the vapor to condense to the liquid form again and fall to earth as rain. Rain water is almost absolutly pure.

Water has great powers for dissolving substances. Almost everything in the world can be dissolved in it. Some substances dissolve very slowly and only in exceedingly minute quantities while other dissolve very quickly and in large quantities. In sinking into the ground or running off to the river or lake, the pure rain water dissolves substances that it happens to meet, thus becoming impure. The quantity of any given substance which the water will dissolve and carry along with it depends upon the readiness with which the substance dissolves and the length of time the water is in contact with it.

Of the many substances that may exist in a dissolved state in water, we are interested in only those which tend to cause scale, sediment and corrosion. These in themselves are quite numerous and a full study of and treatment for them all can be made only by a trained chemist. Hence, when a feed water is causing trouble it is very often advisable to submit a sample to a competent and reliable chemist or company for analysis and prescription or treatment. However, as there are a few impurities which cause the greater part of the trouble encountered, a short study of these, including an explanation of their action, how they are detected, their quantity estimated and a neutralization or elimination effected, may be worth while.

Common Impurities

The commonest impurities found in water are calcium carbonate, magnesium carbonate, calcium sulphate and magnesium sulphate—rather formidable names but really not such formidable substances, because all four of them possess only two elements that can possibly be new or strange to the students of this course. If you have forgotten what an element is, look up the first lesson of the series, Apr. 22.

Calcium Carbonate

The chemical formula for calcium carbonate is $CaCO_3$. This means that it is composed of one combining weight (see May 6 lesson) of calcium, one of carbon and three of oxygen. The calcium is the only element that is new to us. It is a metal but one which is never found in its pure or uncombined state in nature because it is a very active element and readily forms compounds with other elements. Its compounds, however, are very common substances. One of its most familiar and useful compounds is ordinary lime, such as used for making mortar and plaster. The chemical formula for this substance is CaO and its chemical name is calcium oxide. When water is added to lime, making slack lime, the formula is

$$CaO + H_2O = CaO_2H_2$$

Pure calcium can be produced artificially by reducing one of its compounds. When pure and fresh a piece of it looks like zinc. But when exposed to the air awhile it becomes yellowish and finally gray or white in color, due to a reaction between it and the oxygen and moisture of the air resulting in a layer of slaked lime (CaO_2H_2). The combining weight of calcium is 40.1 and, it will be remembered, the combining weights of carbon and oxygen are 12 and 16, respectively. Then, as its formula indicates, calcium carbonate is composed of these three elements in proportion of 40.1 lb. of calcium, 12 lb. of carbon and $3 \times 16 = 48$ lb. of oxygen. Chalk, limestone and marble are all almost pure calcium carbonate.

Pure water is capable of dissolving calcium carbonate in very small quantities—10,000 parts of water are required to dissolve one part of calcium carbonate. That is, to dissolve 1 lb. of chalk would require 10,000 lb. of water or some 1200 gal. and a peculiar fact is that calcium carbonate is less soluble in hot water than in cold. If this was the only rate at which calcium carbonate could get into a boiler (1 lb. per 10,000 of water) there would not be much difficulty in coping with it. But it is not. Carbonic acid or carbon dioxide (CO_2), our old friend which is formed when carbon is burned, can be absorbed by or dissolved in water, and in its descent through the air and travels on and in the earth water does absorb some of this gas. Now, when water containing carbon dioxide flows over chalk, limestone, rocks, marble or other substances mainly composed of calcium carbonate,

e carbon dioxide, water and calcium carbonate all get gether and form a substance known as calcium bicarnate—$CaH_2(CO_3)_2$—a substance which water can disve and carry in solution in quite large quantities.

This calcium bicarbonate, however, is not a very stable mpound. When the water containing it is heated to 0 deg. F. or more, it begins to break up into its three mponents—CO_2, water and calcium carbonate. The O_2 now changes (due to the heating of the water) into gaseous form and, rising through the water in bubbles, capes in the atmosphere. This leaves an excess of calm carbonate in the water, which, as was just stated, only slightly soluble in water. This excess, therefore, ttles to the bottom as a fine powder.

When a substance is suddenly changed to its solid form d settles out of the liquid in which it was dissolved s in the case just described) it is said to have been recipitated" or "thrown down" and the process is lled precipitation.

The foregoing paragraphs show why some boilers are nd to contain internal coatings of soft sand-like or ud-like material. They have been fed with water carryg calcium bicarbonate which the heat has changed back calcium carbonate. As the latter is a solid which can't be vaporized (just like the sea salt) it is left in the iler while the water which carried it evaporates and sses off as steam to the engine or other destination. ch gallon of water fed in leaves its particles of solid lcium carbonate behind and unless blown down and aned often enough the boiler would become choked. This calcium carbonate by itself does not form a hard oublesome scale, but simply a loose mud-like coating hich can easily be washed off the tubes and shell. In ct, a large part of it settles to the bottom of the boiler to the mud drum of its own accord, and can easily be own out. But, as will be seen later, when certain other purities are present in the water, the calcium carbone is cemented into a troublesome scale along with these her impurities.

Magnesium Carbonate

The second commonly encountered impurity in water magnesium carbonate. Its chemical formula is $MgCO_3$. will be noticed that the only difference between this rmula and that of calcium carbonate is that Mg in the esent case takes the place of Ca in the previous one. oth are carbonates, due to their carbon and oxygen con-nt.

Magnesium is also a metal and in its pure state has a ight silvery white appearance. Like calcium it never ists pure in nature as it has very strong tendencies to mbine with other elements. One of its compounds hich is familiar to all is Epsom Salts. The chemical me for this compound is magnesium sulphate, which is cluded in our list of commonly encountered impurities d about which more will be stated later on. Other miliar substances with magnesium in their makeup are lc, asbestos and meerschaum. Magnesia pipe covering composed principally of magnesium carbonate. The mbining weight of magnesium is 24.4.

In nature, magnesium carbonate exists quite extensively d is known as magnesite. It also exists in combination th calcium carbonate, this compound being known as lomite. Magnesium carbonate will not dissolve in re water. But when water containing CO_2 comes in contact with it, magnesium bicarbonate—$MgH_2(CO_3)_2$—is formed and this, like the calcium bicarbonate, is quite soluble in water. When heat is applied, the bicarbonate breaks up and the CO_2 escapes as a gas, just as in the case of the calcium bicarbonate. The passing off of the CO_2 leaves behind an insoluble substance called magnesium hydroxide whose chemical formula is $Mg(OH)_2$. This precipitate being light, settles out of the water but slowly, and in the boiler where the circulation is strong it has a tendency to stay suspended and cause trouble through priming. Another bad quality of this precipitate is its cementing power, which is so great that the stuff is used for making cement for commercial purposes. When it mixes with the otherwise loose particles of precipitated calcium carbonate, a brittle scale results, which cakes on the boiler surfaces.

A Fortunately Contrary Boiler

By Carl H. Beach

A remarkable boiler came to the writer's attention not long ago in a village in Pennsylvania. It had been for 40 years in a wood-working plant where the boiler house, a light frame structure, had twice burned down around it but neither of these experiences seemed to have injured it.

Early in the summer the boiler developed a very bad leak so a boiler maker was sent for. He came, looked the boiler over and made his report which was, in effect: "I can make your boiler tight, but I cannot make it safe and my work will cost you nearly half the price of a new boiler. Your boiler is condemned and it must be at your own risk that you put pressure on it after this."

Since the boiler had held for 40 years and the previous winter carried 125 lb., whereas the usual pressure is only 75 or 80 lb. many men would have reasoned: "The Christmas trade is coming on so we can't stop now. I guess you can make it hold until we get to a more convenient time to stop." Instead, however, the plant was shut down, the old boiler was taken out and a new one put in, even though it meant an idle period of two months.

The old boiler had been dismantled so it could only be conjectured what the setting was. It was a return-tubular boiler about 4 ft. in diameter and 16 ft. long. The old tubes, most of which were apparently those originally put into the boiler, were about 3½ or 4 in. in diameter. There were, however, five tubes that had been replaced at some time, the tube sheet having been reamed out so that the space between adjacent tubes was nearly closed.

The setting was apparently of the extension front type, the front end of the boiler having been suspended from structural work resting on the side walls of the setting. The rear end of the boiler had rested on a brick pedestal in the combustion chamber. The boiler shell where it rested on this pedestal, had been very badly burned so that a hole nearly as large as a manhole had been cut to remove the damaged plate and a patch had been riveted on. The pedestal was then moved forward so as not to bear on the patch and the burning, cutting and patching were repeated, the two holes being separated by about 5 in. of whole plate. Both of these patches were well fitted and fastened in a good workmanlike manner. How the pedestal was placed after the second patch was applied

was not related, but, however it was, the difficulties already experienced only became more widespread. The bottom sheet, including both patches, was very badly burned and had started to bag. The heads of most of the rivets on the patches were burned off and the edges of the plates were so badly burned that there were cracks from the edge of the plate to the rivet hole in nearly every case.

Inside of the boiler the conditions were fully as bad as they were outside at the patched places. There was a handhole at each end below the tubes and by looking through the boiler one could see what appeared to be a heavy coating of scale all over the bottom of the boiler and the tubes that were visible through the handholes. The blowoff pipe entered the front head just below the handhole. Just in front of the blowoff pipe and directly over the fire was a pile of mud and scale fully 2 in. thick that had not been disturbed while the boiler was being rolled some 200 ft. into a field. There is no telling how thick this deposit may have been when the boiler was in service, but it was certainly no thinner.

Above the tubes conditions were not quite as bad as they were below, but even there they were bad enough to make a man think twice before attempting repairs. The heads were braced with diagonal stays of round iron. These stays and the tubes appeared to be badly corroded.

The steam dome was the most interesting part above the tubes. It was about 24 in. in diameter and 30 in. high. The top was flat and braced with round braces similar to those used on the boiler heads. How the braces in the dome were arranged or fastened was not investigated, but that is immaterial, since every one of them had broken, thus allowing the head of the dome to bow outward as though it had been dished in the mill.

Last winter trouble was experienced in keeping up steam when a young man who applied for work was given the job of firing. One day the manager went into the boiler house and found the steam gage showing 125 lb. and the safety valve, which usually blew at 80 lb., as tight as a drum. It was a lever-safety valve and had been held down by adding weights. This was remedied and the boiler was continued in service for several months, or until it developed a leak and the boiler maker was called.

In thinking the matter over one wonders how it happened that the shell at the rear of the boiler was so badly burned and the sheets directly over the fire showed no signs of overheating. Evidently, the explanation is this. The fuel was mill refuse with a little coal mixed in when this proved insufficient. The firebox was probably too low to hold a sufficient quantity of this light fuel, so it was probably crammed full and the fire-doors left open to give draft. This would drive the flame back into the combustion chamber and make it strike directly on the pedestal which must have become very hot and thus concentrated the heat on a comparatively small piece of the shell. Cramming the fuel into the furnace did not leave room for the development of a very high temperature at that point and the boiler shell over the furnace was therefore not burned.

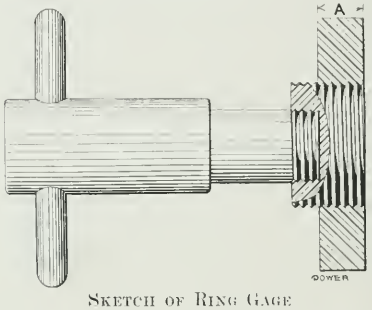
The writer has never seen a boiler that showed signs of distress more plainly nor that had been more abused. The abuse was probably more on account of ignorance of how a boiler should be used than on account of willful neglect.

Application of Briggs Pipe-Thread Gage

On Sept. 17, 1913, the Manufacturers' Standardization Committee adopted officially the Briggs pipe-thread gage for standard and extra-heavy pipe, the resolution presented reading as follows:

"Resolved: That the table and tolerance submitted be approved and that there be deposited with the Bureau of Standards at Washington, D. C., a set of gages to be known as the American Briggs Standard for Pipe Threads."

The gages consist of one plug and one ring gage of each size. The plug gage is to be the Briggs standard pipe thread as adopted by the manufacturers of pipe fittings and valves and recommended by the American So-



SKETCH OF RING GAGE

ciety of Mechanical Engineers in 1886. The plug is to have a flat or notch indicating the distance that the plug shall enter the ring by hand.

The ring gage is to be known as the American Briggs standard adopted by the Manufacturers' Standardization Committee in 1913, and recommended by the Pratt & Whitney Co.

THICKNESS ADOPTED FOR RING GAGE

Pipe Size, in.	Adopted Thickness of Ring Gage "A
⅛	0.180
¼	0.200
⅜	0.240
½	0.320
¾	0.339
1	0.400
1¼	0.420
1½	0.420
2	0.436
2½	0.682
3	0.766
3½	0.821
4	0.844
4½	0.875
5	0.937
6	0.958
7	1.000
8	1.063
9	1.130
10	1.210
12	1.360
14	1.562
15	1.687
16	1.812
18	2.000
20	2.125
22	2.250
24	2.375

In the accompaying table the dimensions are those of the dimension A shown in the sketch, and are the figures adopted by the Manufacturers' Standardization Committee. In the use of the plug gage, the notch on the plug is to gage, and one thread large or one thread small is to be the inspection limits. In the use of the ring gage, male threads are to gage when flush with the small end of the ring, and one thread large or one thread small is to be the inspection limits.

Refractories for the Modern Boiler Plant*

SYNOPSIS—Conditions to be met by firebrick in actual service, kinds of brick and their composition. Increasing the life of furnace arches and a few structural details of firebrick setting.

The use of firebrick is, of course, in lining the side walls of the firebox, in constructing the firebox arch, and coking arch, where such is in use, and in the various forms of baffle tile, to direct and deflect the flames and heated gases.

In the side walls, the brick are subjected to not only the heat of the coal bed, but particularly to the action of the clinker, its tendency to fuse and flux the brickwork and the very severe abrasion of the poker and slice bar as the clinker is removed. The severity of this action is dependent on the coal, the analysis of its ash, the method of firing, draft and numerous other details in connection with its operation.

The arch, however, is subjected to rather different and even more severe conditions. Under the arch, combustion is nearly, if not wholly, complete, and the temperature will be correspondingly higher. Its under side is furthermore continually in the current of a stream of incandescent gases at high velocity, and laden with particles of fuel and ash. Often insufficient opportunity is afforded for radiation and the brick are subjected to such a temperature as makes their life at best a short one. By no means last in importance, however, is the influence of rapid changes in temperature conditions affecting both the side walls and arches, but the latter especially. This may be brought about by opening the firebox doors in firing or cleaning fires, thus allowing cold air to strike the incandescent walls and arch; by opening wide the ash doors when cleaning clinker from the grates in many forms of stoker; or from any procedure which suddenly chills or raises the temperature, even if but locally.

Materials Available

In considering the materials available for this work fire-clay brick, silica brick and bauxite brick have been taken as the only ones which, at present, give promise of being successful on any large scale. Both magnesia and chrome brick spawl far too readily if subjected to a draft of cold air. Because of the fact that the one is highly basic and the other neutral their use has been tried along the clinker line to overcome the trouble due to the adherence of this slag, and while entirely satisfactory on this score, they have been found unsuited for the reason indicated.

Fire-Clay Brick

All fire-clay brick are essentially silicates of alumina and expressed in the lowest terms, are composed of the two varieties of clay, namely, the hard, flint or block clay, as it is often termed, which forms the real body of the heat-resisting material, and the soft or plastic clay, acting as the bond to give physical strength to the brick. As conditions may warrant, a larger or smaller portion of the hard clay may be calcined previous to its manufacture into brick. Upon the character of these clays, the fineness to which they are ground, and the degree of burn given them, depend the character of the brick. In general a fine-ground, hard-burned brick gives superior results in the side walls and a more porous, open, and if it may be so termed, "elastic," brick does better in the arches.

Silica Brick

These are made from crushed ganister rock, with 2 per cent. of lime added, in the form of milk of lime, while the stone is being ground in the wet pan. Analysis of the burned brick will show an average of 1.75 per cent. in lime. A typical analysis is given in Table 1.

TABLE 1 APPROXIMATE ANALYSIS OF SILICA BRICK

	Per cent
SiO_2	96 25
Al_2O_3	0 85
Fe_2O_3	0 82
CaO	1 80
Mg	0 15
K_2O	0 10
Na_2O	
	100 27

Bauxite Brick

As the name indicates, bauxite bricks are made from bauxite ore, a hydrous oxide of alumina containing about 30 per cent. of water, practically all of which is water of crystallization. A fairly representative analysis is given in Table 2. It is mined in this country, in Georgia, Arkansas, Alabama and Tennessee, Arkansas being by far the largest producer. Large quantities are also imported from France. It is hardly necessary to say that the bulk of these various ores is consumed in the production of metallic aluminum, of the various alum salts and of abrasives. Bauxite is exceedingly variable in its composition, and great care is necessary in the selection of the raw ore for the manufacture of refractories and the maintenance of their uniformity.

TABLE 2. BAUXITE ORE

	Per cent.
Fe_2O_3	3 to 6
Al_2O_3	55 to 60
SiO_2	4 to 7
TiO_2	2 to 2 75
H_2O (Water of Cryst.)	30
Moisture	1 50

The ore must be thoroughly calcined at high temperature to thoroughly remove the water of crystallization and so reduce the shrinkage; suitable bonding clays are then added and the brick are burned at the highest temperature of the kilns.

The original troubles in the use of bauxite brick were in a great measure due, not only to deficiencies in the bonding material, but to insufficient calcination of the raw stock, and the attempt to burn at too low temperatures. A high-grade bauxite brick should run as high as, say, 56 per cent. in alumina, a fairly representative analysis being given in Table 3. It can, however, be manufactured with a still higher content of alumina where conditions warrant. The term bauxite as applied to brick is, however, used so loosely that little meaning is conveyed unless at least the approximate analysis is known; many of these brick will show on a determination only from 43 to 51 per cent. in alumina. If prop-

*From a paper read by Kenneth Seaver, on June 3, before the Mechanical Section of the Engineers' Society of Western Pennsylvania, pages 339 to 353 of the July "Proceedings."

erly made, the brick is physically strong and tough, but with somewhat of a tendency to spawl in arches if suddenly cooled or heated.

TABLE 3. BAUXITE BRICK

	Per cent.
SiO_2	38.38
Al_2O_3	56.77
Fe_2O_3	2.95
CaO	0.00
MgO	1.09
Alkalies	0.88

Maintenance of Furnace Arch

In the general development of boilers, a development which has necessitated ever increasing initial temperatures, the general trend has been toward increasing the size of the combustion chamber and the location of the area of complete combustion further from the tubes. The increasing use of the Dutch oven, with its coking arch, and often the combustion arch, is an example in point; so intense is the heat developed that in certain types it has been found absolutely impossible to maintain an arch and the combustion arch has of necessity been discarded entirely. For illustration, certain definite examples will be given.

Fig. 1 shows the sectional elevation of a boiler arch and firebox where serious trouble was occurring in the combustion arch. The brick would spawl, cracking away and dropping from the under surface of the arch in chunks, so that, although the coking arch was unaffected, the combustion arch lasted but two to three weeks. The entire boiler was apparently encased in a steel shell so that the suggestion that the spawling was due in some way to admission of cold air, even with all doors above the firebox level closed, was received with ridicule.

The boiler was, however, shut down, and an inspection of the interior disclosed the following: At *XX* openings had been provided so that the induced draft from the stack would draw cold air from the sheet-iron box covering the coking arch, this casing being provided with slots at the side to cool the suspended coking arch. What was entirely overlooked, however, was the fact that this draft of cold air came directly in contact with the incandescent surface, the under side of the combustion arch. These openings were closed to keep the cold air from the inner arch, thus allowing it to radiate away its heat, and today the life of the brickwork is entirely satisfactory from every point of view.

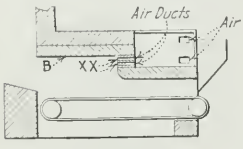


FIG. 1

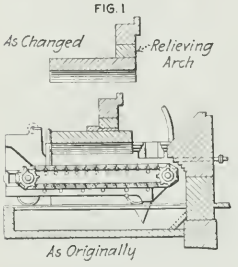


FIG. 2

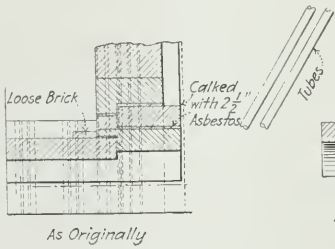
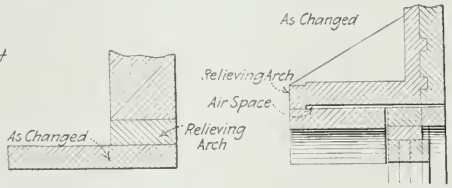


FIG. 3



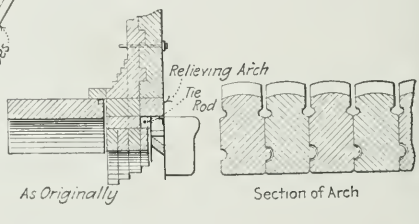


FIG. 4 FIG. 5

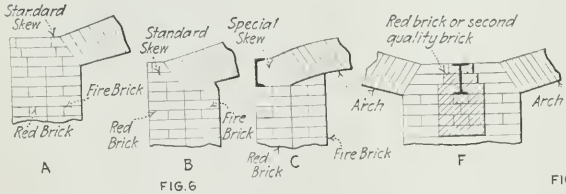


FIG. 6

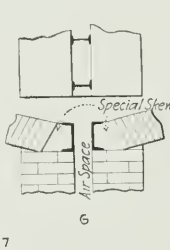


FIG. 7

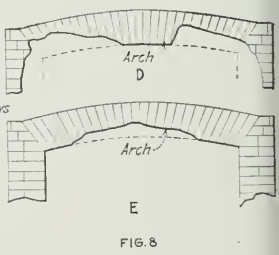


FIG. 8

Fig. 2 shows an installation, the arch of which gave much trouble as originally installed. The diagram indicates one of the familiar types of chain-grate stokers, and this sectional elevation shows the arch, front wall and bridge-wall of the boiler. A portion of the arch extends beyond the front wall, toward the bridge-wall, this extension being 22½ in. directly in the travel of the flame and so located that it was, on three sides, subjected to intense heat, while on the fourth there was little chance for radiation. Furthermore, this arch was rather flat, having a rise of but 7½ in. in 9 ft. 9 in. span.

In the two boilers of this installation the one arch collapsed after two weeks' service, the other after two days. An examination showed what had occurred. The

brick had simply softened and squeezed out of shape, allowing the collapse. The cause was simply the intense heat upon the brickwork without an opportunity for radiation. This was further emphasized by the collection of ash and soot on the upper surface of the arch, which still further insulated it, and by the pressure of the front wall.

The remedy for the situation is shown in the upper portion of this figure. A relieving arch is thrown over the inner end of the combustion arch and the interior front wall of the boiler moved forward at that point to correspond. As rebuilt the arch is giving excellent service, 9 to 15 months, with the same brick as originally installed.

Fig. 3 will illustrate still further a somewhat similar trouble, the lower portion of the sketch being the original installation and the upper portion, as revised. Here is shown a type of split arch. It has its outer end not only subjected to heat on all sides, but the spaces between the combustion arch and the relieving arches calked with asbestos, as is the case in several other instances, as will be noted. In this case not only did the inner combustion arch tend to soften and so collapse, but it pulled forward from the front wall and main portion of the arch and fell forward into the firebox. In three successive installations the arch lasted two days, eight days and nine days, respectively.

The remedy is clearly shown in the upper portion of the sketch. The split arch was done away with, making it a part of the main arch and bonded with it, a relieving arch thrown in directly over it, with all asbestos omitted and the front wall moved forward to the face of the arch. This construction is now averaging six to seven months per arch where there occur exaggerated peak loads and nine to ten months where the boilers are operated at a more uniform rate. All the above installations have one brand of brick and this type of construction has since been adopted by these engineers as standard.

In Fig. 4 is illustrated still another case. As before, the original construction is shown in the lower portion of the plate with the relative position of the boiler tubes. This is typical of three separate plants in mind, one of which gets about 40 days' life, another only about 13, while in the third arches have fallen in from five to six days. At all of these plants they have tried literally dozens of brands of brick with little difference in results.

It is here obviously impossible to move the front wall forward, but the sketch will show the change that has made possible a life of three to six months and in some cases more. It will be seen here that there is a chance for some cooling of the arch, which has none but its own dead weight to carry, and there is no chance for the collecting of ash, soot, etc., on its upper surface, or if such does collect it can be easily removed by a bar through a slot in the furnace wall.

In Fig. 5 is shown one of the typical suspended flat arches. The question is sometimes asked as to the tendency to spawling that is sometimes evident. The flat arch, of course, depends solely for its support on its suspension on metal of some form and often air cooled; the upper surface is cold, the lower hot. In the making of shapes of the size of these blocks the grind and burn must of necessity be such as will make a very much denser brick than is the case with the smaller standard sizes and a brick that will consequently tend more easily to spawl or separate. When this occurs, as it may, for instance, almost in the center of the block, the lower half drops out, while in the sprung arch there is, of course, still the curvature of the arch to hold it in place.

Another common cause of trouble found in various kinds of inclined-grate stoker arches is that of spawling during cleaning of the fires and removal of clinker. Doors are left wide open, masses of clinker sometimes two or three square feet in area may come away and with the ashpit doors wide open a blast of air goes through the grate unheated and strikes the hot brick arch. One can hear the brick snap and spawl and see the clinker drop away.

To summarize, the two main causes of arch trouble are the inrush of cold air and failure to provide for sufficient radiation. A condition illustrating this latter point is the familiar heating furnace in the rolling mill. The bridge-wall without opportunity for radiation may often have to be rebuilt every week or two, while the side walls and roof of the same furnace may last for months.

Structural Details of Firebrick Setting

In Fig. 6 is shown three methods of setting the skew back at *A*, *B* and *C*. That shown at *A* is probably the most common, but has the defect that it is difficult to repair the side walls independently of the arch. One way of avoiding this is shown at *B*, where the spring line is carried to the back wall, using 13½-in. shapes cut to fit until the inner line of the firebox is reached. The same method practically is indicated at *C*, but here a channel is used with special skews. It is evident that the inner wall can be renewed as it is burned or worn away without disturbing the arch.

In Fig. 7 is seen at *F* a type of construction more often used than would be imagined. The I-beam is inserted so that repairs to one arch may be made independently of the other, and the solid partition wall between boilers is still commoner.

It is evident here that there is no chance for radiation, and not only does the center wall tend to soften, allowing the arch to settle, but the beam in many instances has simply burned as a sustaining member. In a number of instances the inner portion of the wall has been constructed of red brick, which later became practically molten, and the entire side wall simply floated into the firebox. A good suggestion is given in *G*, where the wall is split, allowed to cool somewhat by radiation and so much increases the life of both walls and arches as to far more than offset the value of the slight heat losses.

In Fig. 8 at *D* and *E* are shown some typical arches over stokers. The contour of the burned surface indicates the influence of the draft very clearly, and it has so far proven difficult to prevent this channeling.

To consider the influence on the life of the setting of many practices fairly common among masons, the often repeated question might be cited as to whether or not the introduction of a small proportion of lime to the fire clay, thus making it easier to work, harms the setting. There can be cited doubtless thousands of cases where 1.25 to 2 per cent., or even more, lime has been used and the brick apparently remain uninjured, but

where the boiler is hard pushed, it is an element of danger, despite the fact that in many handbooks the use is not only countenanced but recommended.

In a certain boiler of a battery 1.25 per cent. lime was added to the fire clay, to the others none. The arch with the lime stood but a few days when the lime supply fused with the clay to a viscous mass and the brick merely slid from place at a temperature at which the brick themselves were absolutely unaffected. It is not the intention that the brick shall be stuck in place, but the fire clay is merely to fill the slight inequalities and interstices between the brick. They should preferably be dipped and rubbed to place.

When the manufacturer of a high-grade brick begins to insist that it should be laid with a clay corresponding in refractoriness, his motives are not invariably looked upon as altruistic, but this case shows clearly the effect of a comparatively low-grade plastic clay, but yet a fire clay, upon a refractory brick when the temperature is brought well up. Such an action is an everyday occurrence in many plants, and yet the buyer fails to account for the short life from an expensive brick.

Silica brick, more refractory than a clay brick, expand and tend to hold the arch tight and are good, strong brick physically. The great defect, however, is their tendency to spawl, and in the average boiler practice of today they are out of the question because of operating conditions.

In one large central-station plant silica arches were installed and operated with every care, and the management was carefully advised as to the necessities of the case. The life of clay brick had been six months, while the silica gave nearly eighteen months, as constant caution was necessary in firing. There are a number of plants using silica arches, but they are where uniform conditions prevail.

As to the use of bauxite brick for boiler work, although detailed and accurate data are yet hardly available, there are sufficient on which to base the prediction that its use will become general where conditions are severe. Crecelius, of the Cleveland Railway Co., published the preliminary results of his tests in which he showed the apparent absorption of silica by the clinker of the coal and the resistance to such absorption offered by bauxite.

The results show conclusively that bauxite brick are far superior in the particular practice at this plant and indicate that experimenting along these lines is well worth a trial. Its use in the fireboxes of kilns under severe service shows probably treble that of firebrick, but the data are as yet incomplete, nor have the tests in some ten or fifteen power plants yet been sufficiently long under fire to form adequate returns for basing judgment.

⁂

Kentucky Breaks Coal Record—The production of coal in Kentucky established a new record in 1912 with a total production of 16,490,521 short tons, according to Edward W. Parker, coal statistician of the United States Geological Survey. This large output represented an increase of 2,440,818 tons over the figures for 1911, and of nearly 2,000,000 tons over the former maximum output of 1910. The increased production was due chiefly to the new developments in the eastern part of the state. The number of men employed in the mines in 1912 was 24,304, and the average production per man, 678 tons. Kentucky ranks second among the states in the percentage of coal produced by machines, Ohio holding first place. Kentucky is the only one of the coal-producing states which has within its borders two of the distinctly separate great coal fields.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

All in all, this week has been both busy and versatile. We have had the Athletics and the Giants doing battle, Sulzer has had the time of his life, the Episcopalians were in convention, and Yom Kippur (the Day of Atonement) wound up the week. In between, the makers of heat and power kept things moving in a busy burg where things move every minute of the 24 hours.

⁂

The steamer "Rochelle" bumped into a school of "electric" fish off the Gulf Stream and became short-circuited, according to the "Rochelle" salts (meaning sailors). Sounds kind of fishy, though coming from Boston perhaps some fisherman is only codding.

⁂

Why not set Colonel Goethals and his splendidly efficient staff to building an Alaskan railroad? queries "Collier's." This is a good hunch. After his great work on the Canal we don't believe there's much in Alaska that would stop him from earning added laurels.

⁂

William Flewellyn Saunders flew well in our midst recently with a letter saying that the Saint Looey Business Men's League is tickled that its home town "gets the Alaska seal catch." "Flewey" is mixing us up with a skin paper. "The seal has a romantic history," we admit, but Romance can't come in if we see her first. As for sealskin— The Missis will take another season out of "something nobby, $19.98," and Goldstein will put a new velvet collar on ours.

⁂

"In the main building we have a 100-hp. coreless engine," wrote an unmechanical treasurer of a machinery company. First day we have off, we're going to give it a look.

⁂

A newspaper says this happened in a tomato-pulp plant. Just think, if this had occurred in an egg plant!

"An explosion took place at the tomato pulp plant of Williams Bros. Monday afternoon. A mud hole that connects the boiler with the reservoir gave way, blowing the fire out upon the ground. Charles Ankenbrandt was burned in the back and Ed. Mallett scalded on the arms by escaping steam. The plant will be closed for a few days for repairs."

We have a sneaking sorrow, though, for Charley Ankenbrandt and Ed. Mallet getting burned as they did.

⁂

Occasionally, "the man above the dollar" looms large. Thomas Toshesky was entombed eight days in a Lehigh Valley Coal Co.'s mine. Business was stopped while hundreds worked day and night tunneling through 52 ft. of coal. "I thank the good God for the new life!" said Thomas Toshesky, and doubtless he included the company and his fellows as well.

⁂

Marcus A. Dow, the New York Central's safety agent, says we inspect our hogs, protect our forests, conserve the nation's health and life, but—we don't keep our kids off the railroad tracks! And 5284 trespassers were killed last year by the railroads! Guess we'll have to look into this.

⁂

"In Japan it costs each person of its 52,000,000 people an average of $23 a year to live," says "Silent Partner." It must be that twenty-three which incites the little yellow man to skiddoo—and skid quick.

⁂

"Two drummers on a train," says the actress, Helen Lowell, "argued over the vacuum brake's action. It's the inflation of the tube that stops the train," declared the first.

"Wrong," shouted the second. "It's the output of the exhaustion."

When the train arrived at the station, they agreed to submit the matter to the engineer. That gentleman, leaning condescendingly from his cab, listened with an attentive frown to the two travelers' statements. Then he smiled and said:

"Well, gents, ye're both wrong, yet it's very simple. When we want to stop the train we just turn this valve and then we fill the pipe with vacuum."

Reclaiming Fuel from Chain-Grate Stokers

By Everard Brown

SYNOPSIS—By installing reclaiming plates under the chain-grate stokers from 2 to 10 per cent. of the coal was reclaimed. The heat value of this coal was less, however, than that of the fresh fuel.

In the operation of chain-grate stokers there is always a certain amount of fuel lost, due to some of the finer particles sifting down through the bars or links of the stoker and dropping into the ashpit. To a greater or less

TABLE I. TEST ON RECLAIMING OF COAL FROM CHAIN GRATE STOKERS

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Length of stoker	10′ 2½″	10′ 2½″	10′ 2½″	10′ 2½″	10′ 2½″
Width of stokers	9′ 4″	9′ 4″	9′ 4″	9′ 4″	9′ 4″
Length of reclaiming plates	5′ 6″	6′ 6″	6′ 6″	7′ 6″	7′ 6″
Width of reclaiming plates	9′ 4″	9′ 4″	9′ 4″	9′ 4″	9′ 4″
Speed of grate, feet per hour	15 to 18	10 to 16	12 to 16	12 to 15	12 to 15
Condition of coal fired	Wet	Dry	Dry	Moist	Dry
Maximum size of coal fired	2″	2″	2″	2″	2″
Thickness of fire	1″	3½″	3½″	5½″	4½″
Pounds of coal fired	20,480	19,800	19,600	23,630	16,900
Pounds of fuel reclaimed	559	1,962	1,156	936	671
Percentage of total fuel reclaimed	2 73	9 91	5 90	3 96	3 97
Time required for handling reclaimed fuel	17 min.	32 min.	25 min.	14 min.	13 min.

extent this is true of every make of this type of stoker in spite of all arguments to the contrary.

The percentage of the fuel lost in this way depends, of course, upon several things, such as the speed at which the stoker operates; the condition of the coal, whether wet or dry; the thickness of fire carried and the character of the coal as regards fineness, etc. The design of the grate links is also a factor.

In order to determine just how much this loss actually is, a number of tests—results of which are given in the accompanying tables—were made under actual working conditions. No attempt whatever was made to deviate from the regular practice in operating or to do anything that would affect the results one way or the other. The tests were conducted on separate boilers of the B. & W. type, equipped with chain-grate stokers of a well known make.

Under each of these stokers and secured to the frames thereof, reclaiming or recovering plates were installed, varying somewhat in length, so as to get an idea of which would give the best results. Each plate, however, was

TABLE II PROXIMATE ANALYSIS OF COAL FIRED

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Volatile matter	36.00	35 05	34 85	35.90	35 07
Fixed carbon	51 23	50.90	51.72	50.91	51 67
Ash	12 77	14.05	13.43	13.19	13.26
Moisture	10 70	6 50	6 70	7.32	6 00

of the same width as the stoker under which it was placed. These plates were, of course, placed under the front end of the machines.

Because of running these tests under actual working conditions there were a few variables to be contended with, the most important of which probably was the variation in the speed of the stoker. It being rather difficult to accurately time the periods of change in speed, a record was made only of the maximum and minimum speeds. An average of these two would, however, give about the average speed for the full time of the test. Another variable, but not so great, was the character of the coal, it being anywhere from 2 ft. in size down to a fine dust.

The duration of the tests does not enter into considera-

TABLE III. PROXIMATE ANALYSIS OF FUEL RECLAIMED

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Volatile matter	20 62	32 26	31 10	28 44	24.96
Fixed carbon	35 07	51 05	46 48	47 71	42 54
Ash	14 31	16.69	22.42	23 85	32.50
Moisture	2 56	4.59	1 70	1.90	2.39

tion because the information desired and obtained is comparable with the amount of coal fired and not with the length of the tests, size of boilers or amount of evaporation. Furthermore, no saving in dollars and cents is given, as this item depends entirely upon the local conditions and, therefore, would be of no comparative value. A record was kept, however, of the time required for handling the fuel reclaimed by the plates and this is

TABLE IV ULTIMATE ANALYSIS OF COAL FIRED

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Hydrogen	4.96	4 40	4 91	4 58	4 35
Nitrogen	1 15	1.13	1 26	1 20	1 17
Oxygen	6 80	10 31	9 73	10 22	10 10
Carbon	71 34	67.21	68.05	67 90	68 35
Sulphur	2 98	2 90	2 62	2 91	2 77
Ash	12 77	14 05	13 43	13.19	13.26
B.t.u. per lb. dry coal	12,600	11,200	11,890	11,675	11,560

given in the results. This time is only for the one man in each case and covers all of the expense involved.

Another point that should not be overlooked is the fact that the coal reclaimed does not have the same heat value as the original coal so that in calculating any savings in dollars and cents, such savings must necessarily be based upon heat units rather than weights of coal.

TABLE V ULTIMATE ANALYSIS OF FUEL RECLAIMED

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Hydrogen	2 64	4 39	3 81	3 57	3.52
Nitrogen	1 06	1 12	1.20	1 19	1 18
Oxygen	3 67	10 82	8 32	7 30	6 40
Carbon	46 39	64 09	61 70	61 53	53 92
Sulphur	1 93	2 89	2.55	2 56	2.48
Ash	14 31	16 69	22.42	23 85	32 50
B.t.u. per lb	7,950	10,900	10,550	10,420	9,317

TABLE VI. ANALYSIS OF ASH

	Test No. 1	Test No. 2	Test No. 3	Test No. 4	Test No. 5
Volatile matter	1 67	1 40	1.64	3.30	0 82
Fixed carbon	10 43	13 96	8 19	22 92	10 08
Ash	87 90	84 64	90 17	73.78	89.10

A Home-Made Feed-Water Heater

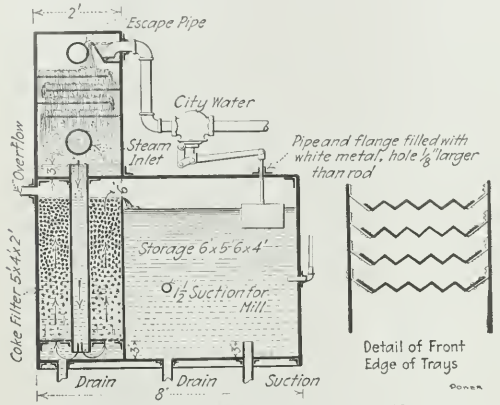
By E. R. Pearce

On taking charge of an old plant the writer was impressed with the large quantity of exhaust steam blowing to waste, in addition to the discharge from about 18 steam traps and various machines using steam for drying purposes.

Permission was granted by the owners to put in any devices that would tend to more economical running. The first thing decided on was to put in a feed-water heater of the open type to handle approximately 45,000 lb. of water per hr., a portion of which was for boiler feed, the remainder being for process work in the factory. On getting in various makers' prices, I was disappointed, as they were much higher than expected, so we turned our attention toward obtaining material with which to make the heater shown herewith.

This heater is giving an average temperature of 190 deg. F. with no steam passing out of the escape pipe. No doubt a little higher temperature might have been obtained had the water been broken up into a greater number of films. The heater did not cost one-half of the quoted prices of others and it gives entire satisfaction.

In one department alone the output has been increased 30 per cent. by their being supplied with hot water, whereas previously they received water at atmospheric temperature and had to heat it with live steam to 200 to 210 deg. F. The heater has cut down the fuel by an average of 448 lb. per hr. The boilers are now much



DETAILS OF HOME-MADE FEED-WATER HEATER

cleaner as the filter seems quite capable of keeping back all the dirt and sediment; the flow through the filter is reversed for a few minutes every evening by opening the drains and shutting the inlet valve.

NEW PUBLICATIONS

THE SCIENCE OF BURNING LIQUID FUEL. By William Newton Best. Published by W. N. Best, of 11 Broadway, New York City. Cloth: 152 pages, 6x9 in.; illustrated; indexed. Price, $2, net.

The book was written by a man whose experience in oil burning dates back to 1887, and as "engineer in caloric" is still engaged in the business. The treatment takes up the origin, production and analysis of liquid fuel, atomization, oil systems, refractory material, locomotive equipment, stationary and marine boilers, ovens and furnaces. A little over half the book is devoted to the subjects last named. Aside from the fact that many of the illustrations have suffered from too much reduction, and that they deal exclusively with the best products and methods, the book contains enough good practical information to be well worth the purchase price.

AIR COMPRESSION AND TRANSMISSION. By H. J. Thorkelson. Published by McGraw-Hill Book Co., New York City. Cloth; 200 pages, 6x9 in.; 143 illustrations; tables. Price, $2, net.

The book aims to present in logical order the fundamental principles dealing with the subject of the compression of air and its transmission. As it is made up from notes used for a number of years by the author in his classes and is thus elementary in character, it is suited for beginners. The field is well covered, as the following list of topics discussed will indicate: Fundamental definitions, thermodynamics of air compression and expansion, air at pressures below the atmosphere and at low pressures above, piston compressors, efficiencies, multistage compression, turbo and hydraulic compressors, effect of altitude, receivers, measurement and transmission of compressed air, and the selection and care of compressors. Appendices on common and Naperian logarithms and a short discussion of hygrometry make a useful addition to the text matter. The book will introduce the student to the broad field of air compression and should be of great service to the engineer wishing to know the wherefore of his compression machinery.

STEAM POWER PLANT ENGINEERING, fourth edition. By G. F. Gebhardt. Published by John Wiley & Sons, New York, 1913; 989 pages; 6x9 in.; illustrated. Price, $4 net.

Since its first appearance in 1908 this work has become to be regarded as a standard reference for practicing engineers on matters pertaining to power-plant engineering. The rapid evolution in power-plant practice and especially prime movers has made it necessary to revise a large part of the text, the chapters on Fuels and Combustion, Engines, Turbines, Condensers and Economics, having been entirely rewritten.

For those not already familiar with the book a list of the subjects covered will give an idea of its general scope: these include, Elementary Steam Power Plants, Fuels and Combustion, Boilers, Smoke Prevention, Furnaces, Stokers, Superheaters, Coal and Ash-Handling Systems, Chimneys, Mechanical Draft, Steam Engines, Steam Turbines, Condensers, Feedwater Heaters, Pumps, Piping, Lubrication, Testing and Measuring Apparatus, Cost of Power, Specifications, Typical Central Stations and Typical Isolated Plants.

The figures on power costs have been gathered from a large variety of sources and include both initial and operating costs. They show clearly the dependence of the latter upon load factor and form one of the most valuable chapters of the book.

RULES OF MANAGEMENT. By William Lodge. One hundred and thirty-nine 5x7½-in. pages. Price, $2 net. McGraw-Hill Book Co., 239 West 39th St., New York, N. Y.

This book is the outgrowth of a series of articles published in the "American Machinist," dealing with managerial and manufacturing experience. The author, William Lodge, is one of the best known machine-tool builders in the United States, and this book has been written from a lifetime of active, varied experience. Although it applies directly to the organization and management of a machine-tool factory, the principles and methods have a wider application. All the members of the executive staff and all shop departments are treated of in detail in a series of helpful rules and comments. The book should be of service to anyone having to do with machine-shop management. The scope of its pages is indicated by the 35 chapter headings, which are as follows:

The Exceptional Employee: The General Manager; Assistant Manager; Chief Engineer and Designer; Drawing Room; Purchasing Agent; Incoming Material and Storage Department; Superintendent of Manufacture; Routing Department; Chief Clerk; Cost and Timekeeping Department; Operation of Premium Plan; Superintendent of Assembly; Handling Complaints; Pattern Shop; Tool-Making Room; Forge Department; Lathe Department; Grinding Department; Drilling Department; Planer Department; Milling Department; Gear-Cutting Department; Special Manufacturing Department; Inspecting Department; Specific Instructions for Painting Lathes; Sales Manager; Shipping Clerk; Boss Laborer and Express Truckman; Millwright and Belt Man; Engineer, Electrician and Oiler; Janitors and Watchmen; A Proposed Pension Plan; Basis on which a Fund Can Be Started.

POWER PLANT TESTING. By James Ambrose Moyer, S. B., A. M.; second edition. McGraw-Hill Book Co., Inc., New York, 1913. Cloth, 486 pages, 6x9 in.; illustrated. Price, $4.

This work has passed to the second edition in two years, having been extensively adopted as a class manual by technical schools and colleges. Sixty-four pages, 120 engravings, and a number of forms and tables have been added.

The chapter on the Measurement of Pressure has been expanded to include barometers; to the treatment of pyrometers, that of electrical resistance and radiation types has been added; the treatment of the indicator has been improved by a discussion of the errors of the diagram, and directions for indicating and computing the horsepower of rotary engines; and descriptions of speed counters and tachometers have been included. A treatment of the differential dynamometer has been added to the section on transmission dynamometers, and the chapter on the measurement of power has been made to include a section on torsion or shaft dynamometers, and the accelerometer.

Pitot tube meters have been included in the steam section and weir meters in the water section of the chapter on the Flow of Fluids. The chapter on Flue Gas Analysis has been amplified by a consideration of the Hempel gas apparatus and a section upon smoke determination. The instructions regarding Reports of Tests in General from the report of the Committee on Power Tests of the American Society of Mechanical Engineers has been incorporated as an entire chapter; and their rules for producer and gas engines, as well as steam plants, incorporated in their proper connection.

A chapter upon Tests of Lubricants has been added, and a

onsideration of air lifts to the chapter upon Hydraulic lachinery. The revision upon which the author places the ost stress is an outline of a series of tests, arranged to suit s nearly as possible, a large number of American technical chools. By the judicious use of these outlines, at least 50 er cent. of the time of an instructor, the author thinks, can e saved, and the efficiency of the courses will be improved.

⁂

RACTICAL ALTERNATING CURRENTS AND ALTERNATING-CURRENT TESTING. By Charles F. Smith, fifth edition. Published by Scientific Publishing Co., Manchester, Eng., 1913. Size, 5x8 in.; 398 pages, illustrated. Price, 6s. net.

The method of presentation is unusual, the principles of lternating currents being approached from the experimental ather than the abstract theoretical standpoint. The treatnent is simple yet thorough, and higher mathematics have een avoided except in the last chapter on the composition of oltage waves. Hence, the book, although intended primarily or students in technical schools, should also appeal to the ractical man desiring an insight into the principles of electricity. Generally speaking, this is perhaps one of the best ll-around books on the subject.

⁂

A table of estimated radiation has just been issued by larry B. Perrigo, of 106 Hobart St., New Haven, Conn. It is rinted upon two sheets of celluloid 4½x7, and gives the quare feet of radiation required for glass and exposed wall urface, or cubic feet of contents. Price, $1.

⁂

"The Polytechnic Engineer"—Vol. 8 of "The Polytechnic ngineer," published annually by the students of the Polyechnic Institute of Brooklyn, has just appeared; 138 pages in ize in cloth binding, and dedicated to Prof. Samuel Sheldon. n addition to institute matter, it contains a number of exellent papers upon engineering subjects.

⁂

The Babcock & Wilcox Co. was one of the first of the arge manufacturing firms to realize that a catalog could dvantageously be something more than a brief for its roduct. Its publication, "Steam," is really a textbook upon ne subject, and its earlier issues are among the prized posessions of many engineers.

The latest edition, which has just appeared, is richer than s predecessors in typography, engravings and contents. nly 78 of its 335 pages are directly devoted to the product of ne Babcock & Wilcox Co., if we except the illustrations of lants with which the volume is interspersed, the remaining ages dealing with such subjects as Heat and Its Measureents; Steam, with an Excellent Abridgment of the Marksavis Tables; Moisture in Steam; Properties of Air; Combuson; Fuel and Combustion; Boiler Tests, etc.

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Annual Meeting of A. S. M. E.

The committee on meetings has arranged the following ntative program for the annual meeting of the American ociety of Mechanical Engineers. A feature will be the preentation of the Grasshof medal, which was placed in the ands of the society to deliver to its past president, George Vestinghouse, at the notable Leipzig meeting. Another event f interest which it is expected will be largely attended is ne German dinner scheduled for Thursday evening of the eeting, at which one of the menus of the German trip will e reproduced and addresses will be given with lantern slides pon incidents of the trip.

TUESDAY EVENING, DEC. 2

President's reception.

WEDNESDAY MORNING, DEC. 3

Business meeting, followed by professional session with ne following papers: "Efficiency of Rope Driving as a Means f Power Transmission," E. H. Ahara; "Comparative Tests of ineshaft Bearings," Carl C. Thomas, E. R. Maurer, L. E. elso; "The Art of Enameling, or the Coating of Steel and on with Glass," Raymond F. Nailler; "Stability in Flying lachines," Albert A. Merrill (contributed by the New York ocal Committee).

WEDNESDAY AFTERNOON

Railroad session, with papers on "Steel Freight Cars" (conributed by the subcommittee on railroads).

WEDNESDAY EVENING

Presentation by the Verein deutscher Ingenieure of the rasshof medal to George Westinghouse, past-president and onorary member.

Arrangements are being made for a lecture to follow the ceremony of presentation.

THURSDAY MORNING, DEC. 4

Professional session, with the following papers: "Pitot Tubes for Gas Measurement," W. C. Rowse; "Tests of Vacuum Cleaning Systems," J. R. McColl; "Tests upon the Transmission of Heat in Vacuum Evaporators," E. W. Kerr; "A New Centrifugal Pump with Helicoidal Impeller," C. V. Kerr (contributed by the New York Local Committee); "A New Process of Cleaning Producer Gas," H. F. Smith (contributed by the Gas Power Section).

Arrangements are also being made for simultaneous sessions on machine-shop practice, cement manufacture, and textiles, by the subcommittees in charge of these subjects. At the machine-shop session, among the topics to be discussed are: "Use of Gears in Machine Tool Drives," "Grouping of Machine Tools," "Cast Iron for Machine Tools," "Flooded Lubrication and Force Fits." The discussion at the cement session will cover the use of powdered fuel and other subjects to be announced later. The textile session will take up cost finding and general efficiency, heating buildings through the sprinkler system, and fire escapes as applied to textile mills.

THURSDAY AFTERNOON

Excursions to points of interest in New York and vicinity.

THURSDAY EVENING

German dinner, reproducing one of the menus from the trip abroad. This will not only be a reunion of those who went on the trip, but is being arranged with a view to giving those who were unable to participate some idea of the many interesting events which the American guests enjoyed. Addresses on the German trip will be made, illustrated by lantern slides. Following the dinner a dance will probably be arranged for.

FRIDAY MORNING, DEC. 5

Session on fire protection. Among the subjects to be discussed are the management of valves controlling automatic sprinkler heads, extinguishing of fires in oils and volatile liquids, and the fire hazard in turbo-generators, contributed by the subcommittee on fire protection.

FRIDAY EVENING

College reunions. The alumni of Stevens Institute of Technology are arranging for a theater party, to which the society and their guests are invited. Supper and informal dancing at a convenient hotel will follow. The alumni of Sheffield Scientific School will arrange a similar reunion.

SOCIETY NOTES

A local association of building owners and managers has recently been formed in Buffalo, N. Y. The following offices are represented: Brisbane Building, Chamber of Commerce, Dun Building, Electric Building, Ellicott Square, Fidelity Building, Iroquois Building, Marine National Bank Building, Morgan Building, Mutual Life Building, Prudential Building, Sidway Building, Telephone Building, White Building.

OBITUARY

PAUL M. J. LIESS

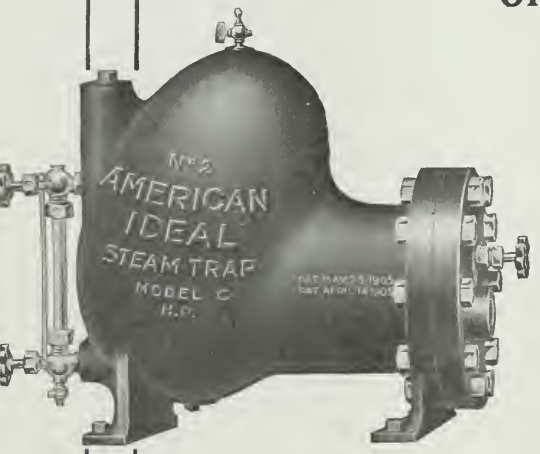
Paul M. J. Liess, chief engineer of the Long Island City power house of the Pennsylvania R.R., died at his home in Brooklyn on Oct. 8 after a long illness. Mr. Liess was 37 years of age. He was a member of the Blue Room Engineers Society.

EDWIN T. MOORE

Edwin T. Moore, secretary and treasurer of the Coatesville Boiler Works and a director and member of the executive board of the Coatesville Foundry & Machine Co., died at his home in Coatesville, Penn., Sept. 25. He was 47 years old. Mr. Moore entered the employ of the boiler works 26 years ago and in ten years became secretary and treasurer. Two years later his remarkable knowledge of all the details of the business resulted in his being made general manager. He was one of the founders of the Coatesville Foundry & Machine Co. and was prominent in Coatesville institutions.

Archimedes Said
I Could Move

We said:—"If a steam tra
enough to sustain a ver
of meeting excessively hig



And So—

The AMERICAN IDEAL STEAM TRAP steps in and fills the bill.

Archimedes never found his fulcrum but we found the leverage necessary to place the AMERICAN IDEAL STEAM TRAP in a class by itself for working under high pressures.

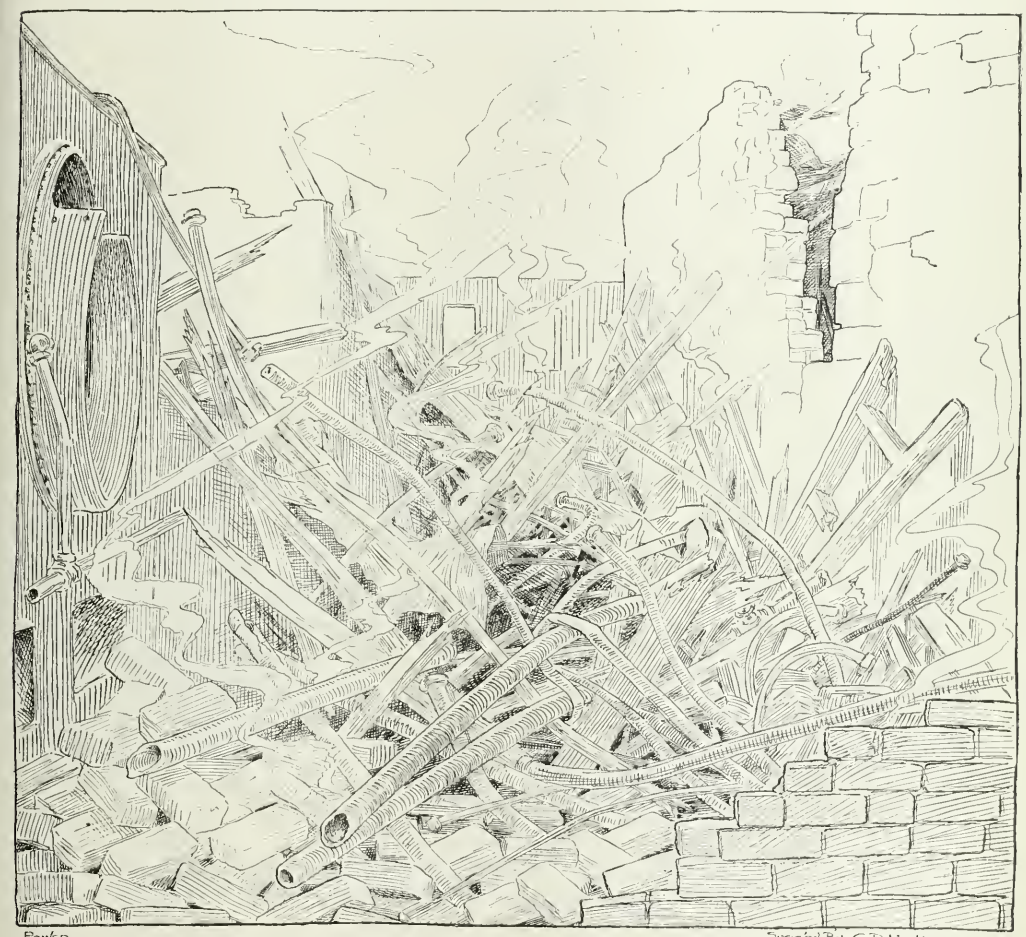
The most powerful arrangement of levers found in any other steam trap is not nearly so powerful as is found in the AMERICAN IDEAL STEAM TRAP.

Pressures that would put other traps out of business are easily within the ability of the "AMERICAN IDEAL."

American Steam Gauge
Camden Street

POWER

Vol. 38 OCTOBER 28, 1913 No. 18



THE PRICE OF A FEW MINUTES' SLEEP

Air in Condensers

By H. Fothergill

SYNOPSIS—An analysis of the various ways in which air may get into condensers, preventing the maintenance of high vacuums, and suggested remedies.

While every engineer knows that air in a condenser s antagonistic to a high vacuum and high condensing fficiency, few realize the importance of it. The ques- ion of air in a condenser is not so vital to the recipro- ating engine, but with the steam turbine, in which ad- antage is taken of the heat units in the steam at lower

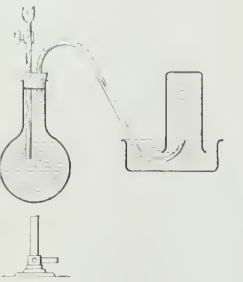


Fig. 1.

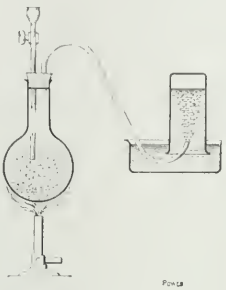


Fig. 2.

Test for Percentage of Air in Water

pressures, to obtain such low pressure, or more generally alled high vacuum, entry of air must be minimized.

To analyze the matter thoroughly it will be necessary o consider separately every way by which air can enter he system and ultimately reach the condenser so as to mpair the vacuum. Beginning at the source of steam upply, the amount of air which enters a boiler depends pon the amount in solution in the feed water plus the mount added by the feed pump. The air in solution n the feed water varies considerably and depends upon he nature of the source of the feed make up, and the neans for discharging the water of condensation from he condenser, which latter question will be dealt with ater.

Feed makeup water, supplied from fresh-water tanks r water mains, is aërated from approximately 3 to 3½ er cent. of its volume, but it is easy to test the percent- ge of air in a feed water. The apparatus necessary, Figs. 1 and 2, consists of a flask connected to an inverted raduated jar, by a pipe, the jar being placed in a vessel n which the water is kept cool by any convenient means. The flask should be entirely filled with the sample of eed water and the glass jar also filled with water, as in Fig. 1; the water in the jar is preferably deaërated. Next eat is applied to the flask, as in Fig. 2, and boiling con- inued until the bubbles cease to rise, when the jar and eaker should be allowed to cool to the same tempera- ure as at starting before taking any readings. The weight f the feed water from which the air has been driven off hould be ascertained before commencing the experiment, o that the volume can be found. The volume of the air riven off is known by measuring the contents occupied y the air in the inverted jar; the percentage of air to he water by volume is equal to the volume of air driven ff multiplied by 100, divided by the volume of water.

The amount of air added by a feed pump depends largely on the type of pump employed. With the old-fashioned, continuous-running, single-acting, plunger pump, the air passed through is a maximum, because the suction pipe of the pump may often be open to the atmosphere. But in modern feed pumps which are independently driven and have their action float-controlled so that the pump speed corresponds to the quantity of water to be dealt with, the suction inlet to the pump is always under water, and, therefore, the least air passes through, such air as does pass through being in solution in the water. Fig. 3 illustrates a convenient float-controlled boiler-feed pump. The tank from which the water is taken is immediately in front of the pumps and contains the float-controlling gear which is connected to the steam-supply valve by the balanced lever at the right side of the tank and the vertical rod. Whenever the water level in the tank falls below a predetermined limit, the steam supply to the pumps is reduced or cut off.

As the liberation of air from the feed water is greatest

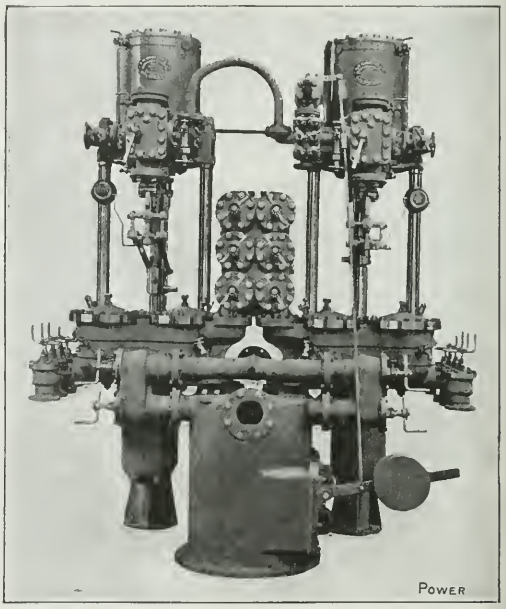


Fig. 3. Float-Controlled Boiler-Feed Pump

when the water approaches the boiling point, it is desirable that an air-liberating device be combined with a feed-water heater through which the water passes before entering the boilers and thus prevent as far as possible the admission of air with the feed water.

Fig. 4 shows a good combined heater and air extractor in which steam enters the central supporting pipe, and after passing through the distributing chamber, flows down through the double coils. The condensed water from the coils is discharged into a hotwell or feed tank. The feed water is heated by contact with coils of gradual-

ly increasing temperature and finally passes through the central discharge tube where it is in contact with the inlet steam pipe, the surface of which is of maximum temperature. The feed water on its upward course through the heater is rapidly raised in temperature, and on passing through the contracted area at the edge of the inverted cone, its upward velocity is so increased that the air bubbles are carried to the surface of the water in the dome where they are liberated and accumulate until the water level is forced downward enough for the float in the chamber connected to the heater to fall and open the air-discharge valve at the top.

Most generating stations have a float-controlled feed pump, or an air-collecting and discharging feed heater,

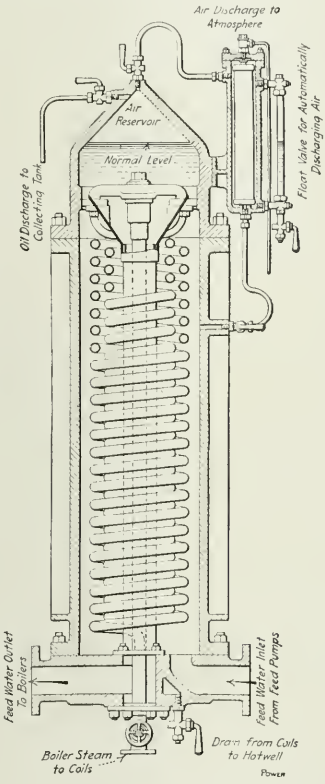

Air Discharge to Atmosphere
Air Reservoir
Normal Level
Float Valve for Automatically Discharging Air
Oil Discharge to Collecting Tank
Feed Water Outlet to Boilers
Feed Water Inlet from Feed Pumps
Boiler Steam to Coils
Drain from Coils to Hotwell
Power

Fig. 4. Sectional View of Surface Feed Heater

and sometimes both; so that little air enters a boiler with the feed water and thence passes with the steam into the condenser.

Investigation has shown that nearly all the air which enters a condenser is due to the leakage of joints and glands subjected to pressure less than that of the atmosphere.

Minimum air leakage is experienced when the steam-condensing and power-producing apparatus consists of a steam turbine having tight glands, few and accessible joints, and the connections to the condenser water sealed. Maximum air leakage is usually found in reciprocating engines, where numerous glands are subjected to a pressure lower than the atmosphere, and where auxiliary engines exhaust into the main condenser. In such plants the actual loss of power on the main unit by air leaking into the condenser through the auxiliary engines, is so great that it may exceed their total power, and, therefore, the auxiliary engines should exhaust into a separate condenser at atmospheric pressure or into an exhaust-steam feed-water heater. This possible loss in power on the main unit is caused entirely by the air drowning of the tubes in the condenser, which results in a reduced rate of condensation and a less perfect vacuum.

If a condenser could be had containing no air, the ideal condensing possibilities would be realized and the condensation of steam under vacuum would be very simple, as the heat transfer through the tubes from the

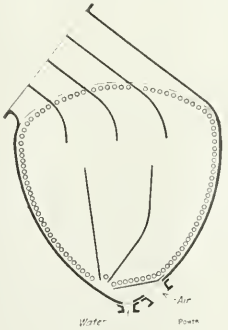


Fig. 5. Contraflo Condenser

steam to the circulating water would be at a maximum for given conditions, thus producing the lowest temperature possible under such circumstances. Moreover, in the absence of air, the temperature throughout the condenser would be approximately the same, and no air pump or air-withdrawing device would be required. However, air being always present, it is necessary to consider how to keep the ratio of air in the condenser at a minimum.

Normally, when a condenser is under load, the air entering and leaving it in a given time is the same; but the ratio of air to steam in different parts of the condenser varies greatly. For instance, at the exhaust-steam inlet of a reasonably air-tight system the air to steam is so small that its effect is almost negligible. As the vapor passes through the condenser and the steam condenses, the percentage of air increases rapidly, until at the air-pump suction the air forms a very considerable proportion of the mixture. The weight of air in a condenser does not depend entirely on the capacity of the air pump, but to a very large extent on the design of the condenser. The high surface efficiency in all modern condensers is largely due to the absence of idle corners or pockets which would soon fill up with the air hanging around the tubes, as the transfer of heat and rate of condensation in such idle parts would be reduced to a minimum.

Another very important feature, which has only recently been emphasized and brought to the notice of engineers by D. B. Morison, is that the steam passing through the condenser should be so directed and guided that its kinetic energy is utilized in driving the air onward toward the air outlet. This feature with others, forms the basic principle of the new Contraflo Kinetic Condenser, the patents for which are owned by the Con-

traflo Condenser & Kinetic Air Pump Co., Ltd., of London. This condenser is of simple construction, as will be seen from Fig. 5, which illustrates a popular design now put forward.

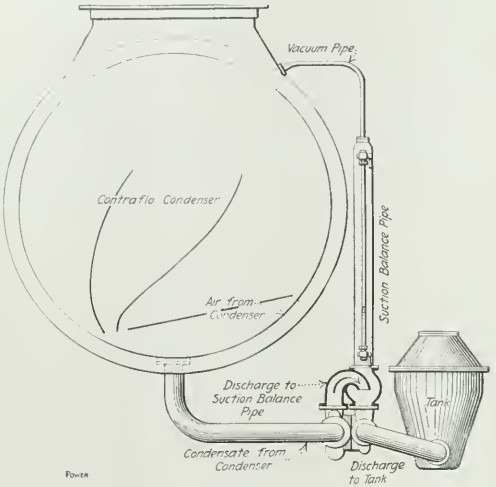


FIG. 6. DIAGRAMMATIC ARRANGEMENT OF TWO-STAGE PUMP DISCHARGING CONDENSATE TO TANK

The reasons which prompted this particular design were as follows: Experiment had shown that condensing efficiency is promoted in a surface condenser when the aërated steam is caused to pass over the condensing surface in a continuous current having uniform distribution and uniform direction of flow toward the outlet from the condensing chamber. It was known from previous experience that the insulation effect of the air particles

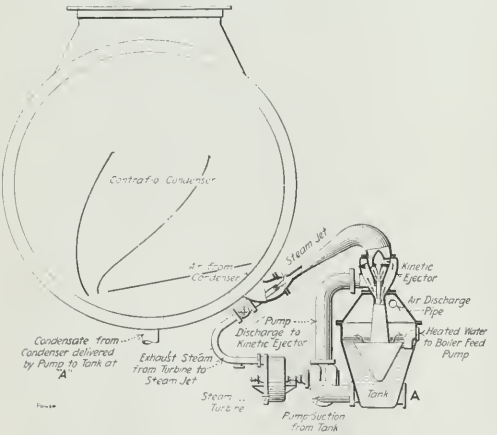


FIG. 7. DIAGRAMMATIC ARRANGEMENT OF KINETIC AIR EJECTOR FOR HIGH VACUUM

which impinge on the tubes at the steam entry is prejudicial to condensing efficiency, while at the exit the air density may be such as to render the tube surface practically inoperative for condensing vapor. Further, the fact was borne in mind that steam enters a condenser, as, for example, from a steam turbine, at a velocity of about 500 ft. per sec., and that at this velocity the kinetic energy of flow is considerable. As a consequence it was decided to direct the incoming steam by plates so as to pass over the condensing surface in a direction to promote stream lines of steam flow vertically or obliquely downward toward the air outlet. Thus the eddying of air particles in their passage through the condensing chamber is prevented and the kinetic energy of steam flow is utilized for, as it were, compressing the air into the air outlet and so assisting the air pump to withdraw the air from the condenser.

When water of condensation is withdrawn from a condenser with the air as by an air pump, it becomes highly aërated, but when withdrawn separately, it may be removed in a state of minimum aëration and delivered direct to the feed tank or feed pump.

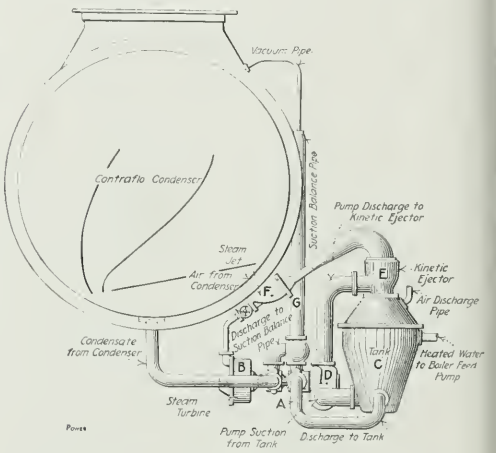


FIG. 8. DIAGRAMMATIC ARRANGEMENT OF KINETIC SYSTEM

Fig. 6 shows a rotary water-expelling device which is now being largely used in England. The apparatus consists of two pumps, the first or head pump discharging into a receiver that is connected to the second or pressure pump. This receiver is also connected to the condenser so as to provide a free escape for any air that may be carried into the receiver in suspension in the water. It will also be noticed that the discharge from the first pump is in the direction of the suction inlet to the second pump, so that the kinetic energy of the water discharged by the head pump assists its flow into the pressure pump. Before head and pressure pumps were adopted, removing the water from a condenser by a centrifugal pump required placing the pump some distance below the condenser to produce such a head on its suction side as would insure its satisfactory working. In the head-and-pressure-pump system the pumps may be practically on a level with the bottom of the condenser, the first pump producing the artificial head on the suction side of the second pump, thus avoiding need of room below the condenser which often is not available, especially on shipboard.

While describing this rotary system of water withdrawal, reference may be made to the Kinetic air pump with which such excellent results have recently been obtained. Fig. 7 shows the system diagrammatically and Fig. 8 the Kinetic air pump combined with the head and pressure pumps. In Fig. 8 the head and pressure pump *A* driven by the steam turbine, *B*, is removing the water from the condenser. This water—the boiler feed—is delivered into the tank *C*, from which it is withdrawn by the Kinetic pump *D* and is redelivered into the tank through the nozzles at *E*. The arrangement at *E* is the Kinetic ejector and is best seen in section in Fig. 7. Its function is to take hold of the mixture of steam and air coming from the ejector steam jet *F* and pass it into the tank *C*. The supply for the steam jet *F* is the exhaust from the turbine *B* and as this steam is condensed by the feed water passing through the water ejector *E*, the whole of the heat in the system is conserved in the feed water and can be returned to the boiler.

Several large installations based on the Contraflo Kinetic principles are under construction, including a large plant for Chicago, which has an overload capacity of 25,000 kw.

From the foregoing it will be seen that the question of air in high-vacuum surface condensers is one that must be considered by every engineer whether he be designing or superintending the running of a steam-condensing plant.

❖ ❖

Some Remarkable Examples of Soot

SYNOPSIS—Some interesting examples of soot formation on boiler tubes, due to lack of frequent blowing the tubes. It is shown that a suitable soot blower will reduce fuel consumption by keeping the tubes clean.

❖

In talking of soot, the average engineer is likely to think of a soft carbon deposit, such as is produced by a smoky lamp. That this impression of the character of soot that collects in boilers is widespread, is evidenced by the fact that in practically all articles and catalogs dealing with the subject of soot, the table from "Kent's Handbook," giving the heat-insulating values of different substances is invariably quoted. The figure for lampblack is then used to show the harmful effect of soot accumulations on boiler tubes.

As a matter of fact, the deposits on boiler tubes have a higher insulating value than lampblack because they increase the depth of the stagnant gas film.

Many engineers also seem to be under the impression that soot will only collect on boiler tubes when bituminous coal is burned. While it is true that soot, in the commonly accepted use of the word, is more likely to form on boiler surfaces when burning soft coal, the accompanying photographs prove that the deposits actually found on the outside of the tubes of water-tube boilers are composed of many substances besides soot and that practically all boilers, irrespective of the kind of fuel burned, are subject to these deposits.

The deposits shown in the illustrations are largely made up of ash carried by the draft and deposited upon the tube. They are also composed of inorganic matter from the fuel which volatilizes in the fire and then condenses when coming in contact with the comparatively cool tube.

When the deposits first occur the ash is in the form of a dust or powder, which can be easily removed, but if the deposit is allowed to accumulate there is a strong possibility that in time it will fuse together, producing some of the clinker formations, as shown.

Undoubtedly the formation of this clinker, which accumulates on top of the first layers of powdered matter, is because the deposit is allowed to become thicker. Its heat-insulating qualities become greater, therefore, the hot gases cannot come into contact with the cool tubes and finally the soot accumulation thickens until a temperature is reached which is sufficient to fuse the material on the top layers.

The sooty deposits found in modern boilers may be classified as: Molten slag, which forms as stalactites on the lower row of tubes when set close to the fire. It is not common and cannot be blown off. Clinker on top of the tube, Fig. 1, found only in the first pass, is a light porous clinker forming on top of the first deposit and shows how the first powdery deposit, which can be easily removed, will fuse together and clinker under the action of heat.

A cemented mass of clinker, Fig. 2, is found only in the lower rows of tubes of the first pass. The deposit is hard, brittle and porous. A scaly deposit is due to moisture in products of combustion cementing the ash deposit. It is frequently found throughout the boiler, Fig. 3. This deposit was taken from the first pass of a B. & W. boiler, using buckwheat coal, having about 16 per cent. ash content, hand fired. This deposit has the appearance of scale, it is white, soft and is made up almost entirely of ashes. The small cakes can easily be pulverized in the fingers, into a smooth, fine powder. It is noncombustible and cakes around the entire tube. It can be easily blown off.

The samples of soot illustrated herewith are not selected ones, but represent the general run of deposits found on boiler tubes. Many of the modern tendencies in boiler practice are conducive to the formation of deposits, such as those shown in the illustrations. One of these tendencies is the use of higher drafts, and the forcing of boilers at continuous overloads. High drafts take up the lighter noncombustible particles from the fire and carry them over and deposit them upon the tube. The more general use of stokers also produces the same result; that is, the burning of larger quantities of fuel per square foot of grate area. High rate of driving also produces higher gas temperature throughout the boiler, making fusing more probable.

One of the harmful effects of such deposits which up to the present time has not been fully appreciated, is that besides its direct heat-insulating value, the porous character of the deposit forms a large number of small cells which are active in retaining the gases of combustion and thus greatly increase the depth of the stagnant gas film around the boiler tubes, which has a marked ef-

fect upon reducing heat transmission. An experiment by Sir John Durston proved the temperature of the gas side to be 58 deg. higher than the water side. In other words, the entire loss of temperature from the 1600- to 2000-deg. temperature of the gases of combustion down to within 36 or 58 deg. of the water is due to loss through the gas film.

The formation of this porous clinker which is so effective in entangling the gases and increasing the depth of the film, also renders ineffective the scrubbing action of high velocity gases in removing the film, which is receiving so much attention at present. Furthermore, when this clinker gets thick enough to bridge over adjacent tubes it seriously interferes with the draft.

Although the first deposits are soft and in the form of powder which can easily be blown off, boilers are often

FIG. 1. CLINKER FORMATION ON TOP OF TUBES

FIG. 2. CLINKER FOUND IN FIRST PASS OF LOWER ROW OF TUBES

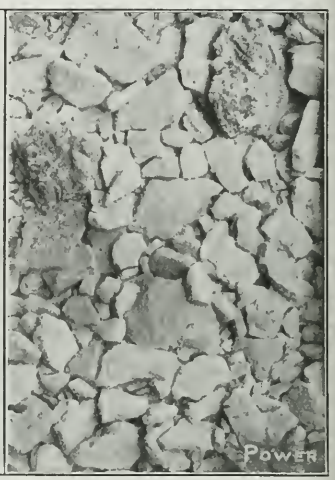


FIG. 3. SCALY DEPOSIT CAUSED BY MOISTURE

installed with the only provision made for soot removal being a few small portholes in the side walls of the setting. Through these doors, some of them at a great height from the floor, the fireman is supposed to insert a perforated steam pipe and blow off the soot. This job is awkward, and as the pipe is hot, the job is shirked as much as possible. This method is also inefficient and primitive, as only the parts of the tubes near the blow doors are cleaned, the soot being blown away from these tubes to those more distant. In fact, no boiler 10 ft. wide can be cleaned by hand unless alley spaces at the side are unusually ample, thus wasting valuable floor space.

The most satisfactory method of thoroughly removing soot and ashes is by means of a suitable soot cleaner installed as part of the boiler equipment. As a result, even the tubes in the center are as effectively cleaned as those on the sides, or in the case of boilers set in batteries, the tubes on the far side are cleaned as thoroughly as those on the alley side.

The operation of such a cleaner is simple, as it is only necessary to open valves, and blow the soot from the tube surfaces. The boiler tubes can be blown frequently, say, once every watch, which is oftener than is ever done by hand. This method of blowing tubes does not reduce the furnace efficiency as no doors have to be opened, allowing infiltration of air. In one large plant now being installed, having 32 boilers, the blow doors are omitted entirely, thus doing away with the source of air infiltration which always reduces the CO_2 percentage.

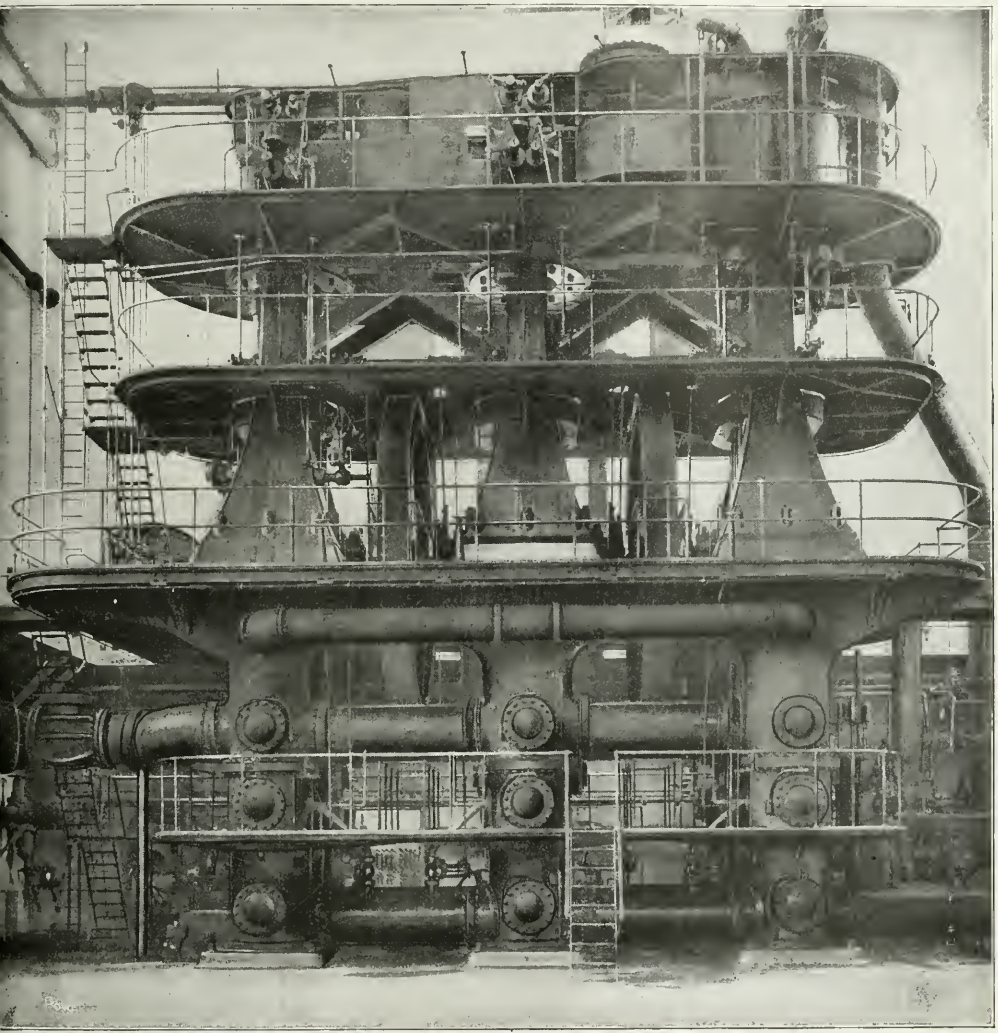
To show that soot results in a higher temperature of gases from the boiler, the following figures were taken at one plant equipped with recording instruments. An average for one month's cleaning the tubes by hand gave a leaving temperature of 517.8 deg. and a CO_2 average of 11.2 per cent. A similar set of readings covering the same length of time when the boilers were blown every day with a soot cleaner gave a temperature of 391.8 deg. and a CO_2 average of 14.8 per cent. The CO_2 percentage is given merely to show that the efficiency of firing in both cases was practically the same.

Thus it is seen that with a soot cleaner the stack temperature averaged 126 deg. lower, corresponding roughly to a saving of 6 per cent. in fuel. Other tests have shown even greater savings. These savings are more than enough to pay for the soot cleaner in less than a year, and besides this must be added the greatly reduced cost for labor in cleaning the boiler over the hand method.

The samples of soot from which the accompanying illustrations were made were secured by engineers of the New York office of the Vulcan Soot Cleaner Co., to whom we are indebted for data contained herewith.

G. Rigg has investigated the causes of the deterioration of firebricks during use ("Journ. Ind. Eng. Chem.," p. 549, 1913), and concludes that other things being equal the resistance to the action of corrosive slags and gases is greater the more compact and close-textured the brick is. "Spalling" of close-textured brick is due to the use of unsuitable clay, or poor workmanship, or both. It is possible to prepare close-textured firebrick containing considerable amounts of coarse material, provided that sufficient care be taken in sizing the grog, so that the interstices between the larger fragments shall be filled as completely as possible by smaller fragments.

Pittsburgh's Large Pumping Engine



7,000,000-Gal. Pumping Engine in the Mission St. Station, Pittsburgh Water-Works System

Herewith is a view of one of the pumps in the new Mission St. pumping station of the city water-works system of Pittsburgh, Penn. This engine is one of two vertical, triple-expansion, high-duty pumping engines built for this station by the Bethlehem Steel Co., Bethlehem, Penn., at a cost of $150,000. The engines pump against a head of 461 ft. and each has a guaranteed duty of 175,000,000 ft.-lb. per thousand pounds of dry steam supplied.

The other principal items in the equipment with their cost and by whom they were supplied are as follows:

Two water-tube boilers, $13,500. E. Keeler Co., Williamsport, Penn.

Electric-generating equipment, $2500. Dravo-Doyle Co., Pittsburgh, Penn.

Electric traveling crane, $4000. Northern Engineering Works, Detroit, Mich.

Steam piping, $7000, and feed-water heater, $1500. National Valve & Manufacturing Co., Pittsburgh, Penn.

Coal- and ash-handling apparatus, $7500. Scottdale Foundry & Machine Co., Scottdale, Penn.

Flue lining, $1700. H. W. Johns-Manville Co., New York City.

Oiling system, $2000. S. F. Bowser & Co., Fort Wayne, Ind.

Terry Return-Flow Turbine

SYNOPSIS—A new turbine in which a novel departure in the internal arrangement apparently solves the trouble from gland leakage.

A new multi-stage condensing turbine developed by the Terry Steam Turbine Co., Hartford, Conn., has several radical departures in details of construction. Fig. 1 is an exterior view of the turbine, Fig. 2, a view with the upper half of the casing lifted, exposing the rotor, and Fig. 3, a sectional elevation.

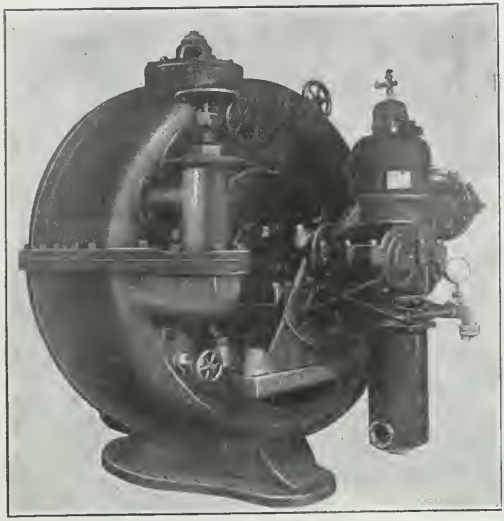


FIG. 1. THE TERRY RETURN-FLOW STEAM TURBINE

One of the new features is the arrangement for overcoming gland leakage, which will appeal to power-plant engineers who well know how difficult it is to locate air leaks in an exhaust system; the manufacturers of the condensing equipment blame it on the turbine glands and the turbine manufacturers invariably blame it on the condensing equipment.

In this machine the low-pressure element has been reversed. The steam, after coming to rest in the high-pressure element at a pressure slightly above atmospheric, flows through an ample passage, as shown in Fig. 3, to the opposite end of the turbine where it returns through the low-pressure element toward the high-pressure end. It is this feature that gives the turbine its name "return flow." The exhaust passage is in the center of the turbine, and the low-pressure gland, which ordinarily is exposed to the atmosphere, has, on its high-pressure side, a body of steam which forms an ideal seal, and what is more important, prevents the entrance of air.

The construction consists in general of a combination of two elements; the high-pressure element taking steam at boiler pressure and expanding it down to practically atmospheric pressure, and the low-pressure element further expanding the steam down to the condenser pressure.

The high-pressure element is identical with the standard single-stage machines manufactured for a number of years by the Terry company, except for refinements o design in the nozzles and stationary passages. As cus tomary in the type the steam is expanded completely in diverging nozzles, the energy then being extracted by suc cessive impulses on the wheel. The return buckets o reversing chambers are designed so that the steam enter both the buckets of the wheel and the reversing chan bers themselves without shock.

After the steam comes to rest in the first stage it i led by a passage over the top of the turbine to the inlet o the low-pressure stages. These stages are of the actio type, each consisting of a series of nozzles attached to a stationary diaphragm and discharging against a singl row of moving blades. Each stage is designed to utiliz the maximum amount of energy available by adiabati expansion between the pressures at the entrance and th exit of the nozzles. After the steam leaves each row o moving blades (except the last) it is redirected into th inlet of the next set of nozzles so that the residual veloc ity is not destroyed in a series of eddies. The result i a higher overall efficiency than would be obtained wer the steam allowed to come to rest after each action.

Ample blade area in the last wheel and low exit veloc ity reduce the carryover losses. Another feature of th low-pressure action elements is the nozzles with machine inner surfaces, which could not be so constructed wer the nozzle plates cast in the diaphragms.

The turbine in general has the usual Terry character

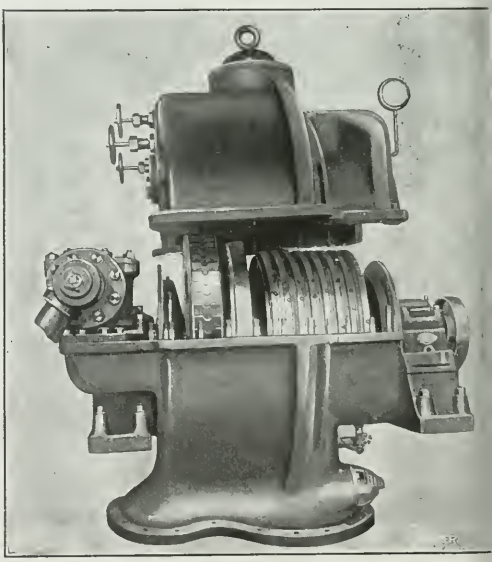


FIG. 2. THE CASING LIFTED, EXPOSING THE ROTOR

istics, such as horizontally split casing, permitting th runner to be removed for examination without disturbin the steam or exhaust connections. The high-pressur element is of the usual Terry type and well fitted t cope with slugs of water should they get through th separator and the governor valve. Another advantage i

at in the high-pressure element large clearances can be ed, for this is where the highest temperatures are found d, consequently, the greatest tendency to distortion. ne machine is less subject to damage from starting up short notice as the point at which the most danger ists when making a quick start from cold is at the high-

signed to give ample steam-passage area as well as provide accessibility for inspection or adjustment. The turbine-casing glands are of the labyrinth type throughout, both between the low-pressure stages as well as at the point where the shaft leaves the casing. No soft packing metal is used in the turbine glands, nor are any lubricants re-

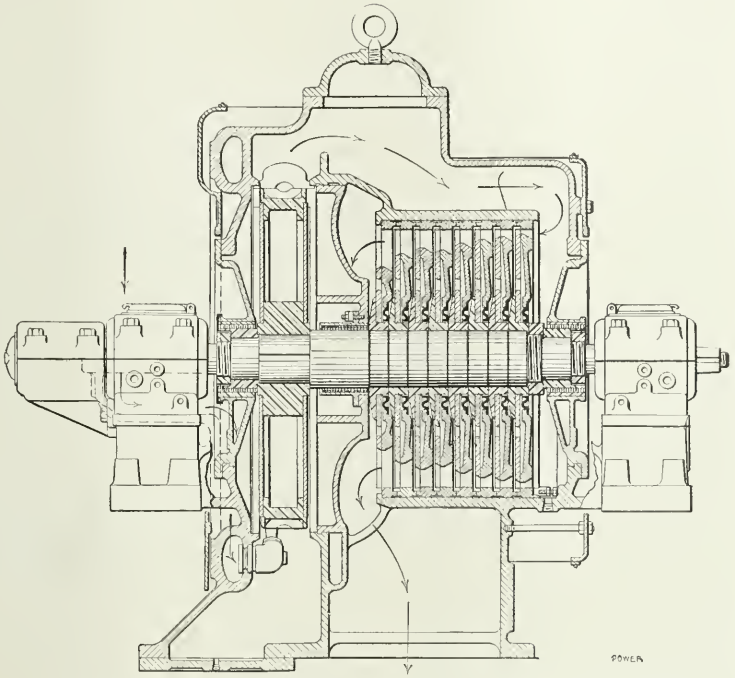


Fig. 3. Sectional Elevation of the Terry Return-Flow Turbine

essure end, where the highest temperatures and the eatest temperature differences exist. This part of the achine being designed with large clearances and with e adjacent parts very heavy, even should rubbing occur, serious results would be experienced.

The low-pressure element is self-contained and can be ted out complete with the shaft. The low-pressure ading is mounted on segments that can be removed for spection without disturbing the wheels or diaphragms. The turbine casing is supported directly from the bear-g pedestals, being attached by a cylindrical web close the shaft. The plane of the pedestal feet is also close the shaft so that trouble from change of vertical clear-ces when the machine is heated up, as well as dangers om casing distortion are minimized. The bearing hous-gs proper are bolted to cylindrical seats in the pedestal bs. The actual surface in contact is narrow and there considerable space between the bearing housing and the destal web, allowing an air circulation that reduces the nount of heat carried to the bearing-oil reservoirs by nduction.

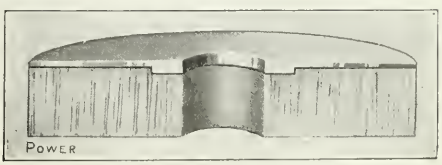
The turbine-governor valve is made in a self-contained it and embraces the main governor, which is fitted with justable and renewable seats, an emergency governor, d a steam strainer. The valve body is carefully de-

quired for any of the glands. It will be found that the outer glands have very little to do other than keep the steam inside of the turbine case, at about 1 lb. or 2 in. pressure, from leaking into the engine room.

Forced lubrication is provided throughout, as well as ring lubrication, which gives a dual system to cover any emergency.

Combination Pump Valve

This valve is made of a composition that will give under high pressure and temperature. In order, however, to prevent the flexible valve from cutting on the



Combination Pump Valve

valve seat, a flat metallic disk of the same diameter as the nonmetallic body is used.

As shown in the illustration, the center of the metallic disk fits in the counter-sunk portion of the valve disk, but is not attached to the valve other than by the fit in the counter-sunk portion. The metal disk is on the bottom side of the valve disk and its object is to resist wear when seating against the valve seat.

The valve is manufactured by the Peck Engineering & Manufacturing Co., 230 Milk St., Rochester, N. Y.

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Solutions for Absorbing CO_2, O and CO

By Charles M. Rogers

The methods here described for mixing reagents for the Orsat or similar hand flue-gas analyzers have been found very satisfactory.

Solution for CO_2

The most important constituent of flue gas to be determined for commercial work is carbon dioxide (CO_2). Its determination is effected by absorption in a solution of either caustic soda (sodium hydroxide, NaOH) or potash (potassium hydroxide, KOH). Of these two, the one most commonly used is KOH. A 33-per cent. solution is best adapted for this work, and is made as follows: Dissolve one part of KOH (stick form) in two parts of water, by weight, and allow to stand until thoroughly cooled before using. This will absorb from 35 to 45 times its own volume of CO_2. That is, if the pipette contains 150 c.c. KOH, it will absorb 5000 c.c., or 5 liters of CO_2. If the measuring burettes are graduated to 100 c.c., the pipette containing the solution prepared as above may be used to make 500 determinations averaging 10 per cent. CO_2 each time. Age has hardly any weakening effect on it. A complete absorption of CO_2 should not take over three minutes. The potash may be purchased from a druggist or dealer in chemicals. The chemically pure (c.p.) stick form is preferable for this work. Care should be taken in handling the caustic potash as it attacks the clothing and skin. The air has practically no detrimental effect on the solution, although it should be kept stoppered as there is a slight change to carbonate.

Oxygen Solution

The solution for absorbing oxygen (O) is not so easily made and requires more care than the caustic potash. Oxygen is usually determined by absorption with either phosphorous or alkaline pyrogallate. The latter will be given here as it is better adapted for use in an Orsat type of instrument, and accurate results may be obtained if proper precautions are taken.

It is well not to mix more than is needed to fill the absorption pipette, as a freshly prepared solution will give the best results, and there is less likelihood of its being spoiled by absorbing oxygen from the air. A good solution is made by dissolving 15 gm. of pyrogallic acid in 50 c.c. of water. The exact proportions are not essential. The pyrogallic will dissolve readily in the water without changing its appearance materially. This is then mixed with about 75 or 100 c.c. of the KOH solution prepared as given in the preceding paragraph for the absorption of CO_2. The solution turns to a very dark-brown color. As soon as the two are mixed the solution is ready for use and should be immediately transferred to the pipette in the Orsat, or placed in a dark-colored and tightly stoppered bottle. Pyrogallol will not spoil by exposure to air while in solution with water, but as soon as it is mixed with the KOH it becomes a strong reducing agent and should be used as soon after mixing as possible. The gas should be passed to and from the pipette about three or four times in 5 or 6 min. At the end of this time the oxygen should be completely absorbed. It is very important that the solution should be freshly prepared and made strongly alkaline by the KOH, as otherwise, carbon monoxide (CO) is likely to be given off as the oxygen is absorbed. This not only shows a lower oxygen but a higher CO.

The solution as prepared above will absorb about 5 or 6 times its own volume if used when freshly prepared; that is, one charge in a pipette should last for about 75 samples, each containing an average of 10 per cent. oxygen. If there is any doubt as to the strength of the reagent, an absorption of the oxygen in the air should be made, and if 20.8 per cent. is not readily obtained, a fresh solution should be made. The pyrogallic acid may be procured from any dealer in chemicals. It is a white, flaky powder and usually comes in tin cans or dark-colored bottles, and should be kept unexposed to the air.

Absorbing Carbon Monoxide

It is difficult to determine accurately the small percentage, if any, of carbon monoxide (CO) in the flue gas; and unfortunately its presence is of vital importance. The usual reagent for absorbing CO is an acid solution of cuprous chloride (Cu_2Cl_2). Enough to fill a pipette can be made by dissolving 22 gm. of Cu_2Cl_2 in 150 c.c. of hydrochloric acid (HCl) of specific gravity 1.12. The acid is only used as a solvent, as Cu_2Cl_2 will not dissolve in water, and, therefore, its exact purity is immaterial. The pure solution is colorless, but upon being exposed to air oxidizes and darkens. This weakens the solution but little, however. It can be kept colorless, or nearly so, by placing a bundle of copper wires in the container. If the oxidation is allowed to proceed until the solution becomes dark green, it should be removed. This solution will absorb less than one-half its own volume. When a sample containing a very small percentage of CO is brought in contact with cuprous chloride that has been used to nearly its capacity, the solution gives off CO instead of absorbing it. It is good to have a small pad or piece of slate tacked beside the cuprous-chloride pipette upon which the amounts of all the CO are tabulated, and when their sum exceeds the capacity of the solution, it should be replaced. The complete absorption should not require any more time than for the oxygen. About three washings in 7 or 8 min. are sufficient, according to the amount of CO. The average time required to determine the three gases, CO_2, O and CO, should not exceed 15 min.

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Chance is frequently at home in the boiler house, when it would not be allowed to enter the engine room, says "Power User," London. If an engineer were to run a heavily flywheeled engine at a speed which, by simple calculation, he could tell was very much too high, and the flywheel burst—where would his reputation and his job go to? Again, assuming he had discovered a suspicion of a fracture in his flywheel, would he be exonerated in the event of a smash, by saying he reduced his revolutions somewhat when he made the discovery? And yet, in the boiler house, where the uncertainty of things is vastly greater than in the engine room, things go on as they are.

ELECTRICAL DEPARTMENT

The Induction Motor—II

By F. A. Annett

Stator and Rotor Constructions

As explained in Part I, the induction motor consists essentially of two elements, a primary and a secondary.

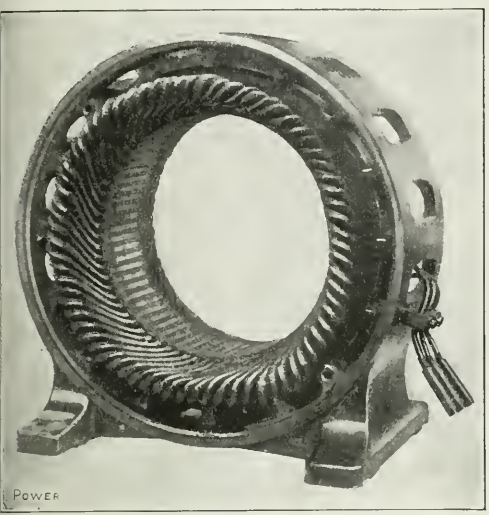

Fig. 7. Core-Frame Three-Phase Induction Motor

netic flux set up by the alternating currents in the stator winding, as was also explained.

Polyphase induction motors in most cases are built for two- and three-phase circuits and are of the squirrel-cage or wound-rotor types, depending upon the class of service for which they are intended. The squirrel-cage rotor type is used in places requiring practically a constant speed under varying loads where a large starting torque is not required, and where the large starting current at the low power factor required by the motor is not objectionable. The wound-rotor type should be used where a large starting torque is required and a heavy starting current is objectionable, such as starting motors on lighting circuits. This type can also be used for variable-speed service requiring practically a constant torque and where efficiency is of secondary consideration. The stator winding for both types is the same, the only structural difference is in the construction of the rotor, as will be explained later.

Five to ten years ago polyphase induction motors built by the various electrical manufacturers had about the same general appearance, but recent years have brought about many departures to improve the operating characteristics of the motor with a reduction in weight for a given output. This has been done by better proportioning of the slots and windings, improvement in the quality of laminated iron and steel used in the cores, better provisions for ventilating and improved methods of manufacture.

The stators of induction motors are built in three general types, the core-frame type, the skeleton-frame type and the riveted-frame type.

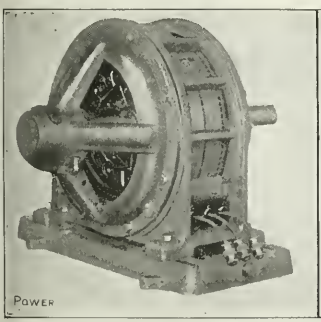

Fig. 8. Skeleton-Frame Motor

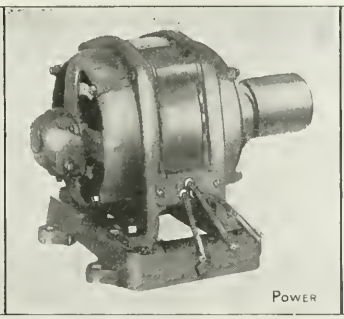

Fig. 9. Riveted-Frame Motor, G. E. Type

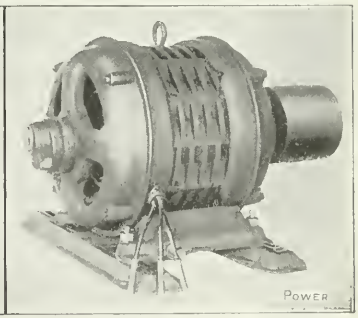

Fig. 10. Riveted-Frame Motor, Westinghouse Type

The primary winding which is connected to a source of alternating current is placed upon the stationary part of the motor, and is usually referred to as the stator; the secondary winding is placed upon the rotating part of the motor and is referred to as the rotor. The latter winding has currents induced in it by the action of the mag-

Fig. 7 shows the stator complete with its winding of an Allis-Chalmers core-frame-type induction motor. The laminated stator core is built up of high-grade electrical steel punchings which are carefully annealed and coated with an insulating varnish. This treatment is to reduce the core losses to a minimum. In the larger motors these

punchings are assembled in the stator frame with spacers introduced at intervals to form ventilating ducts through which currents of air are forced by the rotating member, thereby carrying off the heat from the interior of the machine. Lugs are cast on the inner surface of the frame

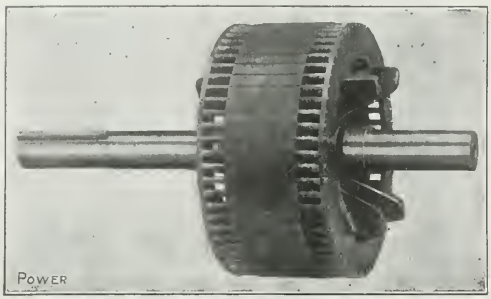

FIG. 11. ROTOR USED IN MOTOR OF FIG. 7

combines great strength with large radiating capacity.

The rotors of polyphase induction motors are built in two general types, the squirrel cage and wound rotor. The rotor core of a squirrel-cage-type induction motor is built up of steel laminations in a manner similar to the stator core. In small sizes the laminations are mounted on the shaft; in the larger sizes they are mounted upon a spider, the arms of which, in some cases, are shaped so as to act as fan blades. The rotor winding consists of a number of copper bars insulated with fiber, each placed in its individual slot and held in place by the overhanging tips of the teeth. In some cases insulating cement is used to insulate the bars in the slots.

One of the weak spots in the early squirrel-cage motors was the connection between the rotor bars and the short-circuiting end rings. From the effects of heavy strains and high temperatures the connections invariably worked loose. To overcome this defect, as well as improve other characteristics of the induction motor the manufacturers have devised the many methods of rotor construction.

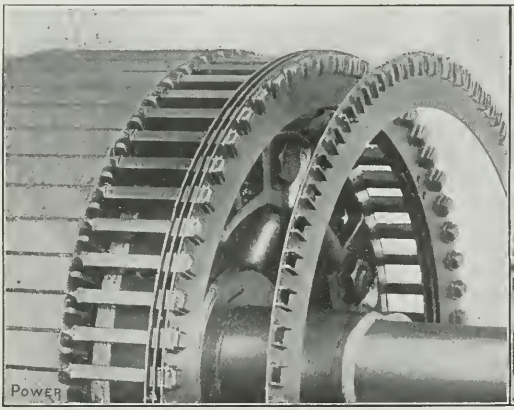

FIG. 12. ROTOR WITH BARS SHORT-CIRCUITED AT ENDS BY THIN RINGS

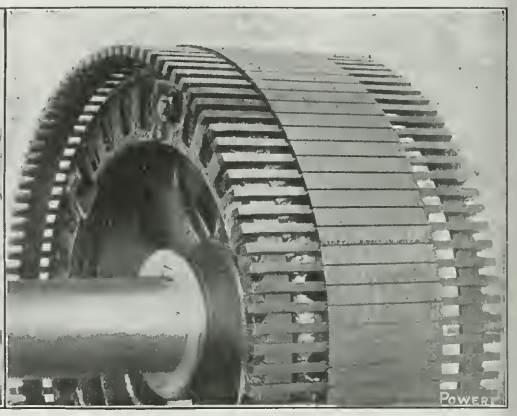

FIG. 13. SHOWING COPPER SHORT-CIRCUITING RING WELDED BENEATH BARS

to support the stator core. A larger space is left between the frame and stator core and holes are cored in the frame which assists in making the motor run cool.

Fig. 8 shows a General Electric Co. skeleton-frame induction motor. It will be noted that all superfluous metal has been omitted, but at the same time the design has resulted in a frame that is stiff and rigid with considerable reduction in weight. The stator core is keyed to the frame ribs and held at each end by iron rings secured to the frame. This type is for sizes above 15 hp.

A General Electric Co. induction motor of the riveted-frame type is shown in Fig. 9. The cored frame usually employed to hold the stator punchings has been entirely eliminated and the weight of the motor is considerably decreased. The laminations are securely clamped between two cast-iron flanges or end plates while under hydraulic pressure. This construction is employed in small motors.

Fig. 10 shows a Westinghouse riveted-frame motor that is built in sizes from 1 to 200 hp. The laminations are riveted under hydraulic pressure between two pressed-steel end rings. The foot or base is of pressed steel and is securely riveted to the end rings. The particular formation of the laminations and the way they are assembled

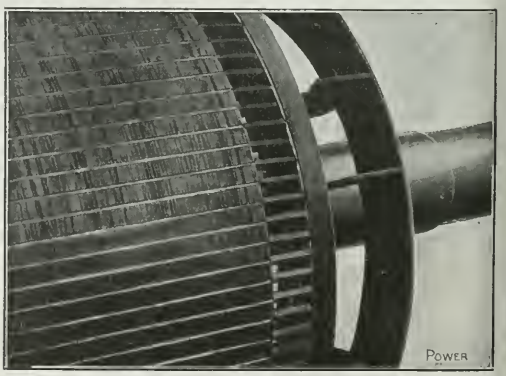

FIG. 14. ROTOR WITH CAST-ON END RINGS, WESTINGHOUSE TYPE

Fig. 11 shows the rotor used in the stator of Fig. 7. The short-circuiting rings, which are copper disks with holes bored in them near their outer periphery to receive

the ends of the bars, are set away from the end of the rotor core, thus allowing projections to be placed on the end of the core to act as fan blades. The short-circuiting rings, being away from the core, will dissipate heat much faster than if in contact with it and, therefore, will be much cooler for a given cross-section. The ends of the bars are turned down and then expanded into the holes in the disks, and, to prevent corrosion, are soldered.

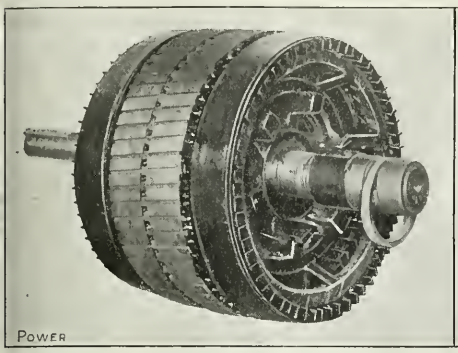

FIG. 15. SHOWING DIAGONAL SLOTS

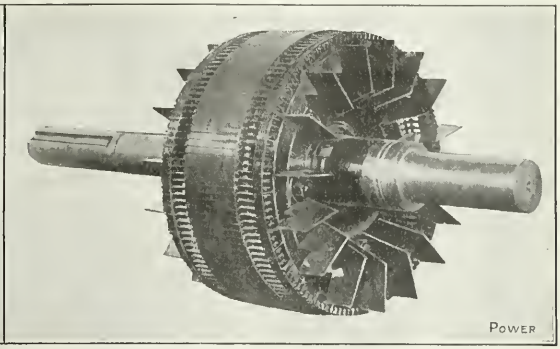

FIG. 17. END RING—HELICAL STRIP ARRANGEMENT

Fig. 12 shows the type of rotor used in the smaller sizes of stators shown in Fig. 8. The bars are short-circuited at the ends by a number of thin rings. These end rings are of considerable radial depth and are held apart by projections formed on the ring itself when the rectangular holes are punched near the outer periphery; the projections also form ample area for soldering the rings to the bars. This multiple end-ring construction affords excellent ventilating facilities when the motor is in operation and the cross-section of the metal can be smaller than for a solid ring. The projecting ends of the bars improve the ventilation of the motor by drawing in currents of air and forcing it through the ends of the stator windings and ventilating ducts in the core. For the larger sized skeleton-frame motors shown in Fig. 8 a welded end ring is used as shown in Fig. 13; a cylindrical copper ring of sufficient cross-section is placed beneath the bars at each end of the rotor and then welded to each bar. This makes good electrical as well as good mechanical connections. The projecting end of the bars have the same effect in improving the ventilation as those in Fig. 12.

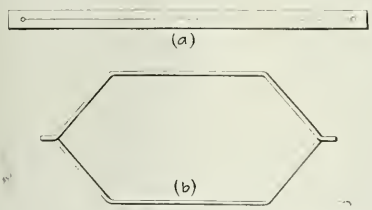

FIG. 16. BAR, BEFORE AND AFTER FORMING

The rotor shown in Fig. 14 is used in the motor of Fig. 10. In this type the bars are insulated in the slots by a special insulating cement. In sizes above 15 hp. the end rings are cast on as shown, which results in good electrical as well as mechanical connection between the rotor bars and short-circuiting end rings.

An interesting example of rotor construction from a mechanical and electrical standpoint is represented in Fig. 15. The slots in the core instead of being parallel with the shaft as in the other types shown are diagonal. Instead of using the usual bar winding the rotor conductors are made by cutting a slit in a wide bar of copper and pulling this out into the familiar form of diamond-shaped coil. Fig. 16 shows the bar before and after forming such a coil; *a* is the copper bar with a slit cut in it and *b* the coil after it has been formed. This construction results in a permanent short-circuit of the rotor without the use of any bolted, riveted or soldered connection. This design is the product of the Burke Electric Co.

Fig. 17 shows the rotor of a Crocker-Wheeler induction motor. The end rings are made up of a helical arrangement of strips. In assembling these segments they are placed on the rotor bars in such a way that each one overlaps the one ahead of it, and in looking down on the rotor the rings have a helical appearance. It is claimed that this type of laminated end-ring construction has a better distribution of the current than where the end rings are made up of complete rings, for the inner rings tend to take more than their share of the current.

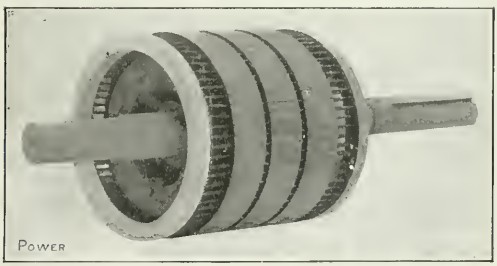

FIG. 18. ROTOR WITH CARBON END RINGS

The rotor of a Fairbanks-Morse induction motor is shown in Fig. 18. The conductors are flat strips of copper placed on edge in the slots. This construction has made it possible to eliminate all insulation between the bars and the slots in the rotor core up to 75 hp. Above this size the bars are insulated with asbestos. The end rings are cast on at a temperature of over 1000 deg. C. After casting, the rings are turned down to size and an inspection groove is cut, as shown, to indicate that the fusion between the ring and bars is complete. The rotor bars have a Sirocco fan effect giving ventilation.

GAS POWER DEPARTMENT

Compression Ratio vs. Efficiency

The effect of compression ratio on the efficiency of a gas engine as given in a paper by Professor Asakawa and J. E. Petavel before the British Association for the Advancement of Science, and reported in *Gas and Oil Power*, is stated in the following conclusions:

"The brake horsepower at full power increases in the same proportion as the theoretical air efficiency, so that the ratio of the two, or the relative efficiency, remains constant at about 55 per cent. Under light loads, the increase of frictional losses with high compression ratios nearly counterbalances the gain in thermodynamic efficiency; and, hence, while the absolute efficiency remains constant, the relative efficiency falls. At all loads, the mechanical efficiency is higher for low compression ratios. At full load, it fell from 79 to 74 per cent., as the compression ratio rose from 3.7 to 5.6; at one-quarter load it fell from 54 to 50 per cent. for the same change of compression ratio.

"The indicated power at full load increases at a higher rate than would be indicated by the air standard, and at light loads at the same rate. Hence the relative indicated efficiency increases at full load and remains constant at light loads. In the tests conducted on a 25-hp. engine and using gas having a lower calorific value of 520 B.t.u. per cu.ft. at 32 deg. F., the consumption at full power was 21 cu.ft. per b.hp.-hr. with the lowest compression: and 19 cu.ft. with the highest.

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The Motorship "Wotan"

Considerable interest was shown in the motor tankship "Wotan" of the Deutsche-Amerikanische Petroleum Gesellschaft which arrived at New York on Oct. 4, and after taking on a cargo of oil at the Standard Oil Co.'s docks, left again on Oct. 8.

Aside from being one of the largest motorships afloat the "Wotan" is propelled by the largest marine Diesel engine that has yet entered this port. This is a six-cylinder, two-stroke-cycle, Reichersteig-Carels engine with cylinders 23½ in. diameter by 13-in. stroke, and developing at 90 r.p.m., 2500 hp. At this propeller speed the vessel is driven at 10 knots per hour.

FIG. 1. MOTORSHIP "WOTAN"

In general appearance the engine follows very closely marine steam-engine design, aside from the cylinders and

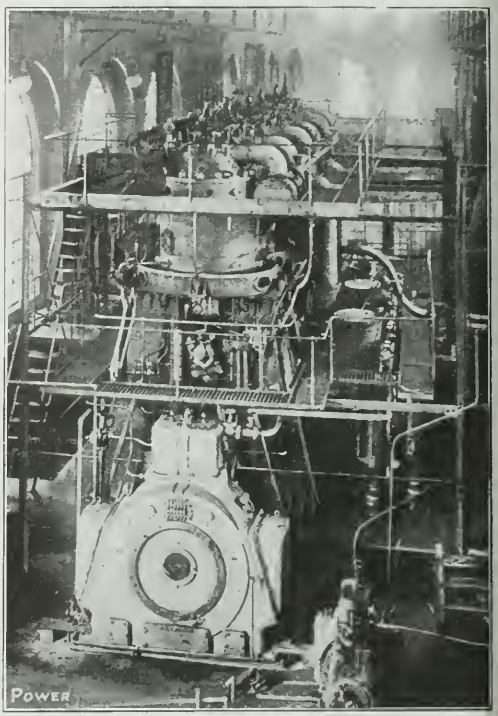


FIG. 2. ENGINE OF THE "WOTAN," SHOWING COMPRESSOR ON END OF SHAFT

valves, of course. The cylinders are supported separately by columns, but are grouped in pairs, thus making a three-section crankshaft, each section of the same length, and thus making it necessary to carry only one spare length. There are two scavenging pumps driven by an oscillating beam from one of the main crossheads. Cooling-water pumps, bilge pumps and a compressor supplying air for the steering engine are similarly driven. Air for fuel injection is furnished by a three-stage air compressor on the Reavell principle, eccentrically driven from the crankshaft. This may be seen at the end of the engine in Fig. 2. An auxiliary air compressor of the same type is driven by a separate four-stroke-cycle engine.

The valve-gear is of the regular Carels design, there being four scavenging valves, one fuel valve and a starting valve to each cylinder. Reversing is effected by turning the camshaft through an angle of 30 deg.

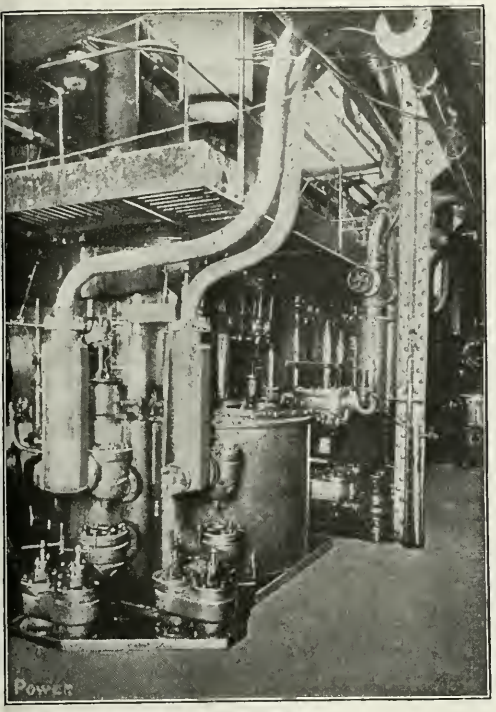


Fig. 3. Scavenging Pumps

Among the auxiliaries there is a steam-driven compressor and two electric generators, one driven by a Diesel and the other by a steam engine.

At sea all auxiliary operations are intended to be performed by oil engines, compressed air or electricity, but for use while in port there is an oil-fired steam boiler to take care of the steering gear, the anchor hoists, windlasses and pumps. While this boiler is in service it also supplies steam for heating. At sea, heating is provided for by a small low-pressure boiler using coke for fuel.

Thoroughness in Purchasing Small Engines

The tendency of many purchasers of machinery to buy equipment in a haphazard manner is one of the chief causes of ultimately expensive service. There is a certain art about spending money efficiently, whether it be for a rug or for a gasoline motor, and the careful buyer who makes a thorough study of the important points to be covered in selecting a machine for a given duty is sure to be recompensed for the trouble such work entails. In buying a small engine, for example, many engineers are content with securing bids from well known manufacturers, calling for prices, guarantees as to performance and economy, and a statement as to the probable or promised date of delivery. This may be well enough in some cases, but what it means to buy an engine after a really thorough study of its features is well indicated by the following list of points recently included for the consideration of prospective bidders to supply an aeroplane engine for military service:

Light total weight, economy of fuel consumption, absence of vibration, smooth running, whether in normal or inclined position and whether at full power or throttled down; slow running under light loads, quality of workmanship, silence, absence of deterioration after tests, simplicity of construction, suitable shape to minimize head resistance, precautions against accidental stoppage, that is, dual ignition, adaptability for starting otherwise than by propeller swinging, accessibility of parts, freedom from fire risk, absence of smoke or of ejections of oil or gasoline, convenience in fitting in aeroplane, relative invulnerability to small-arm projectiles, economy in bulk, weight and number of minimum spare-part equipment, excellence of material, price, delivery and satisfactory operation under climatic variations in temperature.

H. S. Knowlton.

Cambridge, Mass.

Mechanical Efficiency of Gasoline Engines

The mechanical efficiency of any machine is the ratio of output to input. For a steam engine, gas or gasoline engine, this is obtained by dividing the brake horsepower by the indicated horsepower.

It may interest users of gasoline engines of the hit-and-miss type with constant gasoline level feed to know that the mechanical efficiency of such engines can be closely approximated without the use of a prony brake or indicator; simply count the explosions at full load and at no load.

When a gasoline engine is running at normal speed and zero load, fuel must constantly be injected into the cylinder to overcome the friction of the piston rubbing against the cylinder, the friction of the distributing shaft and bearings, the windage friction and the force necessary to suck the mixture into the cylinder. The quantity of mixture thus taken in is directly proportional to the number of explosions inasmuch as the same weight of gasoline is injected into the cylinder before each explosion. A gasoline engine of high mechanical efficiency will not explode as often when pulling zero load as will an engine of low mechanical efficiency.

For example, an engine that I once tested exploded 100 times per minute when pulling full load. With the load thrown off it exploded 20 times per minute. It is evident, therefore, that only (100 — 20) 80 explosions were used in doing useful work. Here 80 explosions are proportional to the brake horsepower and 100 explosions to the indicated horsepower. Hence, the mechanical efficiency of that particular engine was $80 \div 100 = 80$ per cent. The formula for this method is:

$$Mech.\ eff. = \frac{Ne - No}{Ne}$$

Where

Ne = Number of explosions per minute when running at full load.

No = Number of explosions per minute when running at zero load.

Brooklyn, N. Y. S. F. Wilson.

REFRIGERATION DEPARTMENT

Comparative Installation and Operating Costs of a Combined Ice-Manufacturing and Cold-Storage Plant*

By R. H. Tait and L. C. Nordmeyer

The basis of this comparison is a plant having a capacity of 60 tons of ice per day of 24 hr., and a cold-storage capacity of 100,000 cu.ft. The cost of building and machinery equipment is figured three ways: First, with a simple steam plant; second, with a compound condensing plant; and, third, with the Diesel engine. The cold-storage space will require a refrigerating capacity of 20 tons, which is equivalent to 12 tons of ice-making capacity. The refrigerating machines and equipment must, therefore, be capable of developing the equivalent of 72 tons of ice-making capacity for 24 hr. daily.

In the latitude of St. Louis it has been found that if the output of the month of July is figured at full capacity, then the output in July is approximately 15 per cent. of the annual output. In the case under consideration, the yearly work is, therefore, equivalent to

$$\frac{72 \times 31 \times 100}{15} = 14{,}880 \textit{ tons of ice}$$

It is assumed that the plant would be erected in the Southwest, and fuel oil is figured at 95c. per bbl. of 42 gal. Artesian water is available at 87 deg. F. and city water at 90 deg. F.

Buildings

The cost of the buildings, including boiler and engine room, freezing-tank room, cold-storage house and all insulation will be approximately $60,000. The necessary building space will be practically the same for all three types of plant. The fixed charges against the building are for interest, 6 per cent.; insurance and taxes, 1½ per cent.; depreciation, 5 per cent., making a total of 12½ per cent. of $60,000, or $7500 per year. Inasmuch as 14,880 tons of ice represent the year's work, the building charge will be 50.4c. per ton of ice.

Simple Steam Plant

In this plant it is contemplated to use air lifts to pump the water from the artesian wells to furnish the necessary water for the plant in connection with a water-cooling tower. The mechanical equipment will include water-tube boilers, boiler-feed pumps, feed-water heater, smoke-stack, two 60-ton refrigerating capacity machines, ammonia-compression system, distilling system, freezing system, steam and exhaust connections, air lifts and air compressor, circulating-water pumps, cooling tower, piping for cold-storage rooms, brine pumps, brine cooler, all steam, brine and ammonia pipe covering, 60-kw. generator and engine, ammonia, calcium and foundations for machinery. It is estimated that the complete equipment, delivered and erected, including engineers' fees, will be $65,000. The total cost of the plant, including building and machinery, will, therefore, be $125,000. The auxiliary pumps about the plant will consist of duplicate units, one steam-driven and one electrically driven.

It is estimated that there will be burnt 3.08 bbl. of oil per hour under the boilers when operating at full capacity. With oil costing 95c. per bbl. and the capacity being 72 tons ice making, the fuel cost per ton of ice will be

$$\frac{3.08 \times 95 \times 24}{72} = 97.6c.$$

The operating cost is estimated as follows:

Two firemen at $720 per year	$1440
Two engineers at $1250 per year	2460
Two oilers at $720 per year	1440
One handy man	900
Oil, waste, etc.	300
Total	$6540
$\frac{\$6540}{14{,}880}$ =	$0.439 per ton of ice
Ice handling	0.14 per ton of ice
Total operating expense	$0.579 per ton of ice

Fixed charges on the mechanical equipment are for interest on machinery investment, 6 per cent.; insurance and taxes, 1½ per cent.; depreciation and obsolescence, 5 per cent., making a total of 12½ per cent. on $65,000 or $8125. Fixed charges per ton of ice are then

$$\$8125 \div 14{,}880 = \$0.546$$

The total cost per ton of ice is given in the following:

Fixed charges	$0.546
Fuel	0.976
Operating expenses	0.579
Total	$2.101
Fixed charges on building	0.504
Total cost	$2.605

Attention is called to the fact that the total cost of ice, as given above and in the later deductions, is higher than the actual cost of ice at the platform, owing to the fact that the fixed charges on the machinery and building include the fixed charges on the brine cooler, brine pumps, cold-storage house piping, cold-storage house building and insulation which should be properly charged against the cold-storage house only. As these are the same in each case considered, the costs given in each case will not affect the comparison. As the ammonia cost will depend on the care given the plant, and should be the same for each, it has not been used in the estimated cost per ton in making the comparison.

Compound Condensing Steam Plant

In this plant the water will be pumped from the artesian wells in the same manner as in the simple steam plant. The engines on both of the refrigerating machines and on the generator will be compound condensing. The boilers will be equipped with economizers, so that the best efficiency may be obtained in the complete plant. The complete cost of the mechanical equipment, including engineers' commission, is estimated at $76,400.

When operating under full load there will be consumed

*Paper read before the Third International Congress of Refrigeration.

2.38 bbl. of oil per hour, making the fuel cost $2.26 per hour, or $0.753 per ton of ice. The operating expenses for labor, oil, waste, etc., will be $0.579 per ton of ice, the same as for the simple steam plant. The fixed charges against the investment will be

$0.125 \times \$76,400 = \$9550 = \$0.642$ *per ton of ice*

The total cost per ton of ice is, therefore, given in the following:

Fixed charges	$0.642
Fuel	0.753
Operating cost	0.579
Total without building charge	$1.974
Building charge	0.504
Total cost	$2.478

The complete cost of plant is as follows:

Cost of machinery	$76,400
Cost of building	60,000
Total cost	$136,400

Diesel Engine Plant

In this plant city water will be used for the making of raw-water ice and for the cooling-tower make-up. All auxiliaries around the plant will be driven by electric current. Power will consist of two 225-b.hp. Diesel engines, to each of which will be belted one 60-ton refrigerating capacity machine and one 40-kw. generator. The complete mechanical equipment will consist of two 225-hp. Diesel engines, two 40-kw. belted generators, switchboard, two 60-ton refrigerating capacity belt-driven refrigerating machines, compression system, raw-water ice-freezing system, cooling tower, two centrifugal water-circulating pumps, cold-storage piping, two triplex brine pumps, brine cooler, brine and ammonia pipe covering, ammonia, calcium chloride, two oil tanks, foundations for refrigerating machines, Diesel engines, etc. It is estimated the complete equipment will cost $83,923, including engineer's commission.

The fixed charges against the mechanical equipment will be as follows:

Interest on investment	6 per cent.	
Insurance and taxes	1½ per cent.	
	7½ per cent. of $83,923	= $6294
Depreciation and obsolescence on oil engines	10 per cent. of $34,440	= $3444
Depreciation and obsolescence on remainder of machinery	5 per cent. of $49,483	= $2474
Total		$12,212

The fixed charges per ton of ice equal

$$\$12,212 \div 14,880 = \$0.821$$

When operating at full capacity the power required by the refrigerating machine is estimated to be 282 b.hp. at the Diesel engine and for the electric units 97 b.hp., making a total of 379 b.hp. at the engine. Assuming an oil consumption of 8 gal. per 100 b.hp.-hr. there would be consumed 30 gal. of oil per hour, making the fuel cost $16.30 per day, or 22.6c. per ton ice-making capacity. The operating expenses will be as follows:

Two engineers at $1230 per year	$2460
Two oilers at $720 per year	1440
One handy man	900
Oil, waste, etc.	800
Total	$5600
$5600 / 14,880 =	$0.376 per ton ice
Ice handling	0.14 per ton ice
Total operating cost	$0.516 per ton ice

City water must be supplied for making 60 tons of ice and for supplying the losses of the cooling tower. For this purpose there will be used 263,500 cu.ft. of water per month.

70,000 cu.ft. of water costs	$64.15
193,500 cu.ft. of water at 7c. per 100	135.45
Total water cost per month	$199.60
Water costs per ton of ice	$0.09

From the above the total cost per ton of ice is as follows:

Fixed charges	$0.821
Fuel	0.226
Operating expense	0.516
Water	0.090
Total without building charge	$1.653
Building charge	0.504
Total cost per ton of ice	$2.157

The total cost of the plant will be as follows:

Cost of machinery	$83,923
Cost of buildings	60,000
Total cost	$143,923

Résumé

The comparative cost of installation and operation of the three types of plant is given in the accompanying table:

COMPARATIVE INSTALLATION AND OPERATING COSTS

	Simple Steam Plant	Compound Condensing Steam Plant	Diesel Engine Plant
Cost building	$60,000	$60,000	$60,000
Cost machinery	65,000	76,400	83,923
Total cost	$125,000	$136,400	$143,923
Cost water per ton ice			$0.09
Cost fuel per ton ice	$0.976	$0.753	0.226
Fixed charges machinery	0.546	0.642	0.821
Operating cost	0.579	0.579	0.516
Cost per ton ice without building charge	$2.101	$1.974	$1.653
Building charge per ton ice	$0.504	$0.504	$0.504

From the table the following comparisons can be deduced:

Simple vs. Compound Steam Plant: The compound condensing steam plant costs $11,400 more than the simple steam plant, but a saving of 12.7c. per ton of ice is accomplished, which for 14,880 tons of ice-making capacity per year amounts to $1889.76 per year. On this basis the compound condensing steam plant will pay for the difference in cost between it and the simple plant in approximately six years.

Simple Steam Plant vs. Diesel Engine Plant: The Diesel engine plant will cost $18,923 more than the simple steam plant, but a saving is accomplished of 44.8c. per ton of ice, or $6666.24 per year. On this basis the Diesel engine plant will pay for the difference in cost between it and the simple steam plant in less than three years.

Compound Condensing Plant vs. Diesel Plant: The Diesel engine plant costs $7523 more than the compound condensing steam plant, but a saving of 32.1c. per ton of ice is accomplished, which amounts to $4776.50 per year. From this the Diesel engine plant will pay for the difference in cost between it and the compound condensing steam plant in less than two years' time.

From the comparison given above, it seems apparent that the oil-engine plant would be an exceedingly good investment. This should especially be apparent on account of the manner in which the deductions were made. The steam-driven plants were given the benefit of the best efficiency that could be obtained; namely, a boiler efficiency in the case of the simple plant of 65 per cent.; and in the case of the compound condensing steam plant, with the use of an economizer, of 71½ per cent.

The steam consumption of the simple engine of the refrigerating machine was assumed to be 27 lb. per i.hp.-hr., while that of the electrical generators was assumed to be 30 lb. of steam per i.hp.-hr.

In the case of the compound condensing steam plant, a steam consumption of 18 lb. per i.hp.-hr. was assumed for the steam engines of the refrigerating machine, and 20 lb. per i.hp.-hr. for the generator engines, including steam for vacuum pumps and other auxiliaries.

In the oil-engine plant, the engines were credited with a low efficiency of 8 gal. per 100 b.hp.-hr., while it has been found that the fuel consumption of engines installed in the Southwest by the Busch-Sulzer Bros.-Diesel Engine Co. was approximately 6½ gal. per 100 b.hp.-hr. under normal working conditions. In addition to this, the oil-engine plant is charged with water bought from the city, as against artesian-well water used in the steam plant.

A further advantage is given the steam installations by charging them with a depreciation and obsolescence of only 5 per cent. as against 10 per cent. charged to the Diesel oil-engine installation.

The present prices of fuel oil will somewhat change the figures, as shown, but cannot help but prove the oil engine a good investment.

Latent Heat of Fusion of Ice

At the Third International Congress of Refrigeration, in Chicago, H. C. Dickinson, D. R. Harper and N. S. Osborne presented a paper on the above subject, which included a review of previous work and a discussion of the methods used and results obtained by the Bureau of Standards, Washington, D. C. The determinations of the heat of fusion of ice, up to the year 1870, as reviewed by A. W. Smith, are given in Table 1. As may be observed, there is great variation among the results. Many of them were based on but few experiments, and with little doubt were carried out under conditions less favorable than for those made more recently. A summary of the results of the most important determinations subsequent to 1870 is given in Table 2.

TABLE 1. RESULTS OBTAINED UP TO 1870

Name	Date	Number of Experiments	Temperature Range of Water	Heat of Fusion, Calories per Gram	B.t.u. per Lb.
Black	1762	2	80–0	79 7	143 5
Wilke		1	72–0	72	129 6
Laplace and Lavoisier	1780	2	100–0	75	135.0
Provostaye and Desains	1843	17	24–10	79 1	142 4
Regnault	1842	4	16–7	79 24	142 6
Regnault	1843	13	22–11	79 06	142 3
Hess	1848	40	19–7	80.34	144.6
Person	1850	6	16–5	80 0	141 0
Bunesn	1870	2	100–0	80 02	144.0

TABLE 2. RESULTS OBTAINED SUBSEQUENT TO 1870

Name	Date	Number of Experiments	Heat of Fusion, Calories per Gram	B.t.u. per Lb
Smith	1903	8	79.59	143 3
Rogojawlensky	1904	6	79.61	143.3
Behn (calculated by Roth)	1905		79 69	143 4
Dieterici (calculated by Roth)	1905		79 60	143.3
Mean			79.62	143 3

By the Bureau of Standards, the heat of fusion of 92 individual ice samples has been determined by either the electrical method or the method of mixtures, both of which are thoroughly explained in the paper. Of these the first 50 determinations were made on samples cooled in cryostats antedating those described in the paper, in which the temperatures and the distribution of temperature were not so well known. These observations, which include commercial plate, can and natural ice, as well as ice frozen in the laboratory from double-distilled water, both free from air and containing air, showed no difference greater than one part in a thousand in the heat of fusion for these various samples. However, on account of the uncertainty in the initial temperature of the ice, the results were omitted from the paper.

Four observations on samples of ice artificially contaminated with a mixture of equal parts of ammonia, sodium chloride, and calcium chloride, to the extent of about one part in a thousand, gave results about 1.4 per cent. lower than for pure ice. From the remaining observations the results may be summarized as follows:

Five observations by the electrical method on samples of commercial plate ice gave for the heat of fusion 79.65 calories per gram mass, with a mean variation of 0.02 calorie.

Five observations by the electrical method on commercial can ice gave 79.65 calories per gram mass, with a mean deviation of 0.02 calorie.

Eight observations by the method of mixtures on commercial can ice gave 79.61 calories per gram mass, with a mean deviation of 0.02 calorie.

Five observations by the electrical method on Maine natural ice were made, of which three were consistent with each other and with other results, while two differed so much from the other results as to justify their omission. The three determinations gave 79.65 calories per gram mass, with a mean deviation of 0.01 calorie.

The mean of the results by the electrical method is 79.65 calories if the ratio of the calorie to the joule be taken as 4.187.

The mean of the results by the method of mixtures is 79.61 calories, independently of the ratio of the joule to the calorie.

The mean of the 21 observations gives for the heat of fusion of ice 79.63 calories per gram mass, or approximately 143.5 B.t.u. per lb., weighed in air against brass or iron.

In another paper before the congress, A. Leduc, professor at the Faculty of Sciences, Paris, after a review of previous work and a discussion of the possible causes of error, decided that a value of 79.6 calories could be taken as the latent heat of fusion of ice with an error less than one in a thousand.

The second section of the congress proposed that the value 143.5 B.t.u. per lb. be adopted as the universal standard for the latent heat of fusion of ice, but as far as we are aware no action has been taken, and the matter will probably go to the next congress, to be held in Russia three years hence.

Surface ice doubtless protects the water during the severest winter weather, but it must be remembered that it also shuts off the sun's rays which are copiously absorbed by the water. The increasing power of the sun in the late winter and spring is a powerful factor in elevating the water temperature; but an opaque coating of ice keeps the water cold and hence tends to preserve the ice sheet. It has been found that about 25 per cent. of the sun's heat actually penetrates the ice sheet. I have observed the ice sheet of Lake St. Peter, on the St. Lawrence, move out at least ten days earlier than usual by the expedient of opening a space in the river above the lake by means of an ice-breaker, and thus allowing the water flowing into the lake to accumulate the full power of the sun's rays.—Prof. H. T. Barnes, of McGill University.

EDITORIALS

Refrigeration and the Present Needs

Popular conception links the field of refrigeration with ice-making plants, cold-storage warehouses and breweries, and few except those having an intimate acquaintance with the subject realize the magnitude of the industry and the prospects for the future. It is generally known that the use of artificial ice is on the increase, but perhaps it is not realized that the manufactured product is gaining the ascendency over nature's store.

Figures given out by S. S. Van Der Vaart at the recent congress in Chicago, indicate that in New York City sixty-five per cent. of the ice consumed is artificial. When a number of plants now in progress of erection are completed, it is expected that the above percentage will reach three-quarters of the total output. When this proportion is compared to less than one-fifth nine years ago, the rapid growth will be evident. In cities near our northern boundary and even in Canada, where natural ice is plentiful and cheap, ice-making plants have been installed or are contemplated, and in time the use of a considerable amount of artificial ice may be expected.

In the United States it is estimated that there are thirty-five hundred ice-making plants, with a total annual output of eighteen to twenty million tons. The capital invested in the ice-making industry proper is not less than a hundred and fifty million dollars. In refrigeration, including cold-storage and all other cooling, fully fifty million more is invested in machinery. The possibilities here are enormous. Refrigeration is now applied to approximately a hundred and fifty industries, and every day sees some new application or extension to those existing. Refrigeration is now used in the laundry, in the mining and paper-making industries, in silk and woolen mills, in the preservation of seeds, in the manufacture of a great variety of products and even in the cure or prevention of tropical diseases.

Notwithstanding the technical and economic importance of refrigeration and the advanced development of the science in the leading countries of the world, education along this line has not received its proper share of attention. The rapid development of the past few years calls for a change. Men educated to design and efficiently operate the various systems employed are in demand. Due to some extent to the efforts of the International Association of Refrigeration notice of the conditions existing is being taken at educational centers. In some cases special courses have been provided, in others, elementary instruction and in many more full recognition is given to the importance of the field. The laws governing refrigeration and the intricacies of the science are in a class with those of steam engineering and are as difficult to master. Hence the need for thorough instruction and the installation of complete courses in all engineering schools.

Prompt action is needed if the number of men trained to the science is to meet the demand. The growth or extension of the refrigerating field has not reached the high-water mark. It is only beginning. The increase in the immediate future should be rapid, and the calls for men will be more and more numerous. In the past our great universities and technical schools have not hesitated to add to their instruction or establish new courses when the need became evident, and it is confidently expected that they will meet the present requirements in the refrigerating field.

Your Son's Vocation

The *American Lumberman* has made a suggestion that has been flatteringly indorsed by men prominent in its field. It is to have a "Junior Day" at their annual conventions to which the sons of the lumbermen will be invited. This is only part in a larger plan to make the business attractive to the sons so that they will follow in their father's footsteps if they appear to have a bent that way.

So much by way of submitting a similar thought to engineers. How to make engineering appeal to the growing boy. There is much to be said on both sides as to the desirability or nondesirability of having the young man follow his father's profession. On one point certainly all will be agreed. It is positively wrong to coerce the youth into any line of work that he is not in sympathy with or for which he has no natural fitness. When a boy has had sufficient opportunity to judge of his father's business or profession and decide whether or not he wishes to engage in it, then, by all means, he should be left absolutely to make his own decision. If an attempt is made to force him into an uncongenial line of activity he will start with a handicap that almost certainly will defeat his succeeding. Many obstinate fathers have made this mistake.

On the other hand, there are those who have been so anxious not to unduly influence their sons that they have gone to the other extreme. As a result the sons have felt their sires either had no interest in them or positively did not want them to follow their lead. Where a man has failed of success himself he may naturally discourage his son's taking up the same line of work. Having succeeded in his own chosen field, a father has no excuse for failing to acquaint his son with the work so that the boy can judge of his interest in it. Once convinced of a youth's desire to enter a certain field and the probability of his succeeding in it, it is pure neglect for a father to fail in opening opportunities for him.

Entirely apart from the question of good to the individual is the one of the best interest to the world at large and progress. Is it wise to keep a line of descent in one field of work, or, as the farmer has learned, is it preferable to have "rotation in crops," so that the soil may be most fruitfully used? Is there any analogy? Is the race benefited by not having the brains of any one family too long devoted to the same purpose? Will there

be a freshness of material for development along new lines every generation or so?

No doubt some will be reminded of the vocations in which skill pays a large part, and many generations have been carpenters, or weavers, or expert artists or artisans of one sort or another. Who can deny that heredity played a large part in the ultimate proficiency secured?

So much by way of opening up the subject for our readers' thought and consideration. We are not prepared to settle the problem for anyone. We do believe, however, that it will work itself out in almost any case where the father is not too busy or indifferent to take any interest in it. The boy should neither be slighted nor driven. Let him know his father's profession first, then if he prefers another he should not be prevented from embracing it.

⁂

Municipal Ownership

Against the municipal ownership and operation of a power plant to supply a city and its inhabitants with light and power, the favorite argument is "politics." And quite naturally, for when politics are allowed to interfere it is impossible to make a favorable showing in the plant. In a great many cities of this country business-like methods are not employed. Red-tape and political considerations form a serious handicap and even where criminal graft is not present, favoritism and influence have an effect which usually result in the city paying more for the land, the construction of the building and the entire power equipment than it would cost a private corporation. Even after the plant has been put into operation this same influence might increase the price of the fuel and supplies and so control the employment of the management and labor as to preclude efficient results.

The answer to such an argument is easy. Remove the plant from politics, see that competent men are appointed to run it, and an important point is to pay liberal salaries for services rendered. A good engineer in a large plant is worth his weight in gold. When a municipality recognizes the truth of the above assertions, and adopts them, there will be no chance for failure.

Under the above conditions the municipal plant has all the advantage. It can borrow money for construction and equipment at a lower rate than an individual, and then there are the dividends which, if there are any in a municipal plant, revert to the consumers of current and insure a rate lower than could be given with profit by a private corporation. In the plant the boilers, engines and generators do not care who owns them. Put them into the hands of men equally competent, who are given a free swing and are held responsible for results, and they will produce current as cheaply for the people as for a corporation.

As expressed in these columns some years ago, the results will speak for themselves. The business of producing electricity is becoming systematized. The cost of the plant per kilowatt, the cost of generating current and the cost of distribution are becoming well known and any deviation one way or the other can be easily detected. The consumer would know by the price he is paying for light or power.

A notable example of a municipal plant operated on the above lines is the one at Pasadena, Calif. According to the sixth annual report which is abstracted on other pages of this issue, the plant has been remarkably successful. Great credit is due the management and indirectly the city, whose broad policy has made efficient conditions possible. Based on the old rates charged by its present competitor the municipal plant has saved sufficient to pay for itself in five years. On sliding rates of five to three cents for lighting and four to one- and two-tenths cents for power the plant has made a profit of 8.18 per cent. Before the inauguration of the municipal plant a base rate of twelve and one-half cents was charged for the first 666 kilowatt-hours. The enormous difference is evident and not only Pasadena, but also the surrounding cities were benefited.

Such instances as these tend to restore confidence in public ownership and show that a municipal plant run on a business basis is not only practical, but will pay large returns on the investment.

⁂

Causes of Steam-Plant Troubles

One reason why some purchasers of power-plant machinery are always in trouble is that they assume that they know more about the operation of the machine than do the manufacturers. Because of this assumption, impossible operating conditions are imposed upon the machine and economical results are then expected.

Often operating conditions are aggravated by the use of second-hand pumps, engines and boilers. A defective pump can be an element of danger by failing to deliver the necessary amount of water to the boilers. For instance, in one plant a single-cylinder power pump was used as a boiler feeder. Although the lift was not great the pump frequently failed to pick up after being stopped. On one occasion the engineer did not notice that the pump was not pumping water until just before the water went out of sight in the water glass of the boiler. A greater delay in discovering the fact would have ended in trouble.

A defective engine may be an instrument of danger because of the absence of a decent safety stop or having none at all. There are hundreds of patched engine frames in use that are more fit for the scrap pile than for withstanding the strains produced by the power strokes of the piston. The owners take a chance that the engine will hold together a few days, weeks or months longer.

Most dangerous, however, is the second-hand boiler, the boiler that has been in operation for years and subjected to ignorant abuse, or the boiler that is carrying a higher steam pressure than safety warrants. In case of accident there is no excuse for the owner of such apparatus to hide behind.

If machinery is operated in defiance of the advice of men who know their business, the blame for resulting troubles must rest on the unwise owner.

Advice freely given is seldom heeded. If paid for it is taken at a greater value, but it is useless to pay for advice if it is not to be followed in putting in the work contemplated, or in operating the equipment after it has been installed.

⁂

Just because there are CO_2 recorders, steam-flow meters and draft gages in the boiler room, don't think the fireman is a combustion engineer. His pay envelope tells him that the firm does not think he is.

READERS WITH SOMETHING TO SAY

Wants to Clean Producer Gas

We plan to install instruments for measuring the heat value of the gases from our gas producers. These gases are not cleaned or scrubbed, but are used in the raw state and therefore contain a high percentage of tar, which must be taken out before the gases enter the instrument.

Perhaps some of the readers who have had experience with gas producers will be kind enough to answer through these columns how we can satisfactorily filter or scrub the gas. We have 16 producers and the pipe lines to the instruments will be direct from each producer to the instrument.

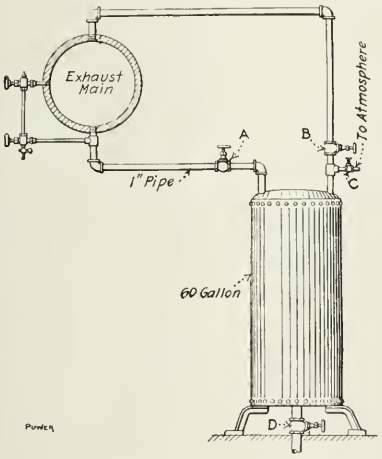
Will a coke filter be of any use or would it be advisable to clean the gases by water alone?

F. D. Harger.

New York City.

Condensate Accumulator for Exhaust Line

We have a 750-kw. two-stage, vertical turbine which exhausts into a barometric condenser. From the outlet in the base of the turbine to the vertical exhaust riser of the condenser is about 15 ft. In this horizontal pipe



Connections for Condensate Receiver Tank

much condensed water would accumulate which was both troublesome and dangerous, as the exhaust base of the turbine might be flooded. The use of a trap for removing this water was suggested, but the following plan, which was simple and inexpensive, was adopted and gave complete satisfaction.

The exhaust line was tapped and threaded near the condenser for 1-in. pipe, one hole being tapped in the top and the other in the bottom, as shown. From these two holes, two 1-in. pipes, led into a 60-gal. tank, placed on the floor. These two lines were fitted with valves and a tee was fitted with a pipe and valve opening to the atmosphere. In the bottom of the tank, a 1½-in. pipe fitted with a valve was connected for draining the tank.

In addition a gage-glass was connected, the bottom to the pipe at the lower outlet, and the top at one-half the diameter of the pipe from the bottom. As soon as water shows in the gage-glass, the attendant closes the valves *A* and *B*, and opens the valves *C* and *D*. This allows the tank to be rapidly drained. After draining the water, valves at *C* and *D* are closed and *A* and *B* opened, which again connects the tank to the exhaust line.

James M. Purcell.

Richmond, Va.

Getting Clear Water from a Muddy River

The following problem is a very practical one because one similar may be "put up" to some reader at any time, and to solve it is not a very easy matter, until one knows how. In fact, I have known many engineers to doubt the possibility until they were given the facts.

The principles used in the solution described can be applied to similar problems by bringing about the same conditions, which existed naturally in this case, through artificial agencies, if necessary.

The problem in its original state was as follows: A brewery had been built on the high bank of a large river which was always muddy, and the building was about 50 ft. back of the river's edge, owing to the steep slope of the bank, as shown. It was not intended to use this river for supplying the water as another source appeared available, until the owners found out that the water they had anticipated using would not be supplied them. Under such conditions they called in a consulting engineer and told him to get them a suitable supply of water, without requiring a considerable outlay, no filtering apparatus was desirable if it could be avoided, but the water had to be clean and in large quantities.

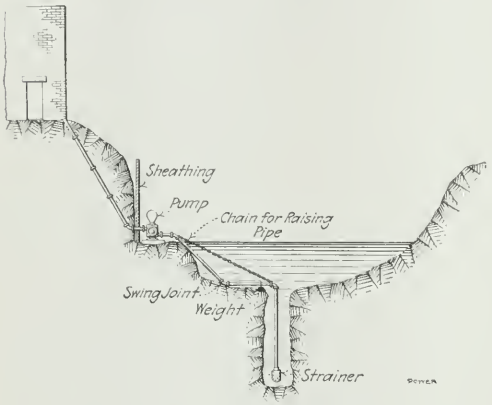
It was interesting to get a solution of this problem from the data as it was thus submitted. It may be added that the colder the supply of water obtained was, the greater would be the economy of the plant.

The consulting engineer decided that the river was the most feasible source of supply to look at first, but it was so muddy with a clayey kind of soil that he was very nearly discouraged at the outset. However, hiring a boat he took a trip across the river and made a series of soundings, and in one place about 50 ft. from the bank on which the brewery was, he discovered a hole about 40 ft. deep in the rived bed, the general depth of the river was 50 ft., so that the distance from the surface of the river to the bottom of the hole was about 90 ft. The next day the engineer made a special arrange-

ment of bottle so that he could get a sample of the water in the hole, and immediately proceeded to locate the hole and get the water. On getting the sample to the boat he found it was clear and on testing its temperature found it approximately 50 deg. F. This temperature was afterward found to be practically unvariable throughout the year. On testing the river water he found it was muddy all above the hole and had a steady, slow current.

Having found a source of clear water the problem was how to get it to the brewery without having it contaminated with the muddy water. This part of the problem was solved by anticipating that the hydrostatic pressure of the river would force it up into a pipe extended with its open end into the hole and clear water.

The whole problem was then solved by running a pipe line from the brewery to a pump installed at the water's edge, and supplying the pump from the hole by means



Piping Arrangement for Getting Clean Water from Muddy Stream

of a pipe line run from it to and into the hole in the river bed. To make the line in the river readily accessible for inspection and repairs it was installed with a swing joint that would permit the length of pipe to the hole to be raised by means of a chain permanently fastened to it, the pipe being raised and moved sideways to allow it to rise out of the hole. A weight was also put on the pipe to keep it in place when lowered into the river.

In using the water it was only necessary to run the pump a few minutes to clean out the muddy water which had got into the pipe on lowering it, and then raise the water from the river, a distance of about 10 ft., and then force it up the hill. The supply satisfied the owners and it is believed to be the main supply up to the present time.

The reason why the water at the bottom of the hole or rather near the bottom is clear, is, in the writer's opinion, because the water in the hole is still, this permits all solid matter in this water to settle (under the action of gravity). The muddiness or color of the water is caused by solid matter, that is, earth or clay in a very minute state. This solid matter cannot settle easily in a flowing river, unless it is of considerable length and passing through a rocky country, but remains suspended, keeping it muddy; but where the water becomes still enough, the solid matter will settle.

It is true that muddy water must be supplied to the hole in this case, as some is taken up by the pump, but such muddy water soon gives up its earthy matter and is "lost" in the great quantity of clear water already in the hole and does not appreciably affect the clearness of the supply. In fact, the flow of water in the hole being downward, due to the position of the inlet, will tend to assist gravity in settling the solid particles.

The presence of the hole is apparently due to a peculiar rock formation in the bed of the river. It would seem that this condition might be duplicated by driving a tank into a river bed where such a natural condition did not exist; the top of the tank would not necessarily have to be below the river bed.

The reason why the water in the hole was of a uniformly low temperature during the whole year, was apparently due to the tendency of the cold water (being denser) to keep to the bottom strata of the river during the summer, and in winter the warmer water would be at bottom of the river while the freezing water and ice were on top, and this would make the temperature at the bottom of the hole about 48 deg. F. in winter and in summer the temperature would not be much higher for the reasons already stated.

A. P. Connor.

Washington, D. C.

Position of Jam Nuts

The learned discussions of the proper location of jam or locknuts take me back to the time when I was a cub in the shop. Theoretically the thin nut should probably be underneath. Practically it is a nuisance to put it there, owing to the necessity of using a thin wrench.

But why all the fuss over it anyhow? The check nut alone is stronger than the bolt if it is a halfway decent fit as can be proved by pulling a bolt in two with the nut. So it is entirely unnecessary to waste time discussing whether to put it inside or outside, for either place is good enough.

But why use locknuts anyhow? The automobile builders have abandoned them for the castle nut and the locomotive builders are following suit. A few thin washers of varying thickness will take up anything needed, even on large bolts and the cotter pins make a positive lock.

John R. Godfrey.

New York.

Soda Ash for Boiler Waters

The article by Charles H. Bromley, on the above subject, in the Sept. 16 issue, brings up several points that deserve further explanation. Soda ash is very widely used as a preventive of corrosion in boilers, and the common practice does not generally conform with the ideas contained in that article. At the outset attention should be called to the author's own correction of the amount of soda ash that needs to be present in the water to give a "safe" concentration; that is, a concentration at which corrosion is prevented. In place of 55 grams per liter the author intended to state 1.59 grams per liter as the minimum amount of soda ash necessary to prevent corrosion, which correction appears in Mr. Bromley's note

n the Sept. 30 issue of POWER. This concentration is till higher than it is necessary to carry in the boiler to prevent corrosion, as is daily demonstrated by users of oda ash in the boiler-feed water, the reasons for which re:

1. Under boiler pressure some of the soda ash is converted to caustic soda. This reduces the concentration of oda ash necessary to prevent corrosion, as was demonstrated by Heyn and Bauer and Cribb and Arnaud.

2. The inside of the boilers is dark, and light very naterially hastens corrosion, as Cribb and Arnaud, and Friend have demonstrated. The experimenters that ave investigated the corrosion of iron in a solution of oda ash have conducted their experiments in glass beakers exposed to the light.

3. Where soda ash is added to the boiler water a slight protective coating of calcium carbonate is deposited on he boiler tubes and plate. If the water has been properly treated by soda ash before entering the boiler, this oating will be soft and the tubes will have the appearance of being whitewashed.

For the above reasons experience has demonstrated that a concentration of soda ash high enough to prevent corosion may easily be carried in the boiler. Sea water and ome natural waters contain magnesium chloride. The nagnesium chloride breaks up under boiler pressure, orming magnesium oxide and hydrochloric acid. Such vaters must contain a higher concentration of soda ash o neutralize this hydrochloric acid.

The above mentioned article referred to the corrosion of the steam main that sometimes takes place where soda sh is used to prevent corrosion in the boiler and gave as ts cause the "unsafe" concentration of soda ash that is leposited on the main when the boiler primes. Probably he greater cause for this is the corroding oxygen that is driven off from the boiling water in the boiler. The corosion in the boiler was prevented by the soda ash, but he lack of it in the steam main caused the oxygen and team to be very corrosive. Where corrosion of the boilers is due to the oxygen, the boiler-feed water should be eated by an open feed-water heater before going to the oiler, rather than to depend upon any chemical reagent o prevent corrosion. Experience has shown that where o oxygen is present, pure water is not capable of causing orrosion.

JOSEPH D. VODER.

Philadelphia, Penn.

The Factory Fire Chief

Mr. Koon, in the Sept. 23 issue, in regard to the requirements of the factory fire chief, states that the use of utomatic sprinklers would make the fire chief wholly unecessary, and that there would be no serious losses from ire, etc. The sprinkling system is a great thing, but ike everything else mechanical, it frequently fails to ork as it is supposed to, and the more modern the fire ystem is the more apt it is to be complicated. And very engineer knows that complicated mechanism of any ind requires very close attention to keep it in proper orking order; hence the necessity of a fire chief.

Whether or not this office should be filled by the engieer depends on many circumstances. From the viewoint of an engineer it seems out of place to require him to assume the additional duties of fire chief as he already has enough to do for the wages he gets. In looking at it from the company's standpoint the chief engineer is the most logical employee to be chosen as fire chief. He more thoroughly understands the equipment, such as pumps, hose, extinguishers, piping, etc., and the care of them, because it is part of his business as engineer to know these things, and part of his equipment of pumps and help would be called into play in case of fire.

The extra work added to the oftentimes overworked engineer might make it necessary to put an additional man on the force under the engineer. The average chief engineer could also assume the duties of fire chief without any trouble. I believe that the greater part of the engineers would be willing to assume the additional responsibility provided the pay is increased in proportion. The objections of the employer to increasing the pay is usually the cause of the trouble in such cases.

J. C. HAWKINS.

Hyattsville, Md.

Graphite Remained in Economizer

E. C. Sutton's letter in the Aug. 19 issue, concerning the failure of graphite to prevent scale forming in his boilers, was read with interest.

Mr. Sutton may have improperly fed the graphite, for if the graphite was properly distributed in the boiler the scale would not be white.

I have been using graphite for boilers for some time and I am satisfied with results. At first I was disappointed with the results in one plant and was about to notify the makers of the graphite, when it occurred to me that it was very queer that if I was feeding graphite there should be no trace of it in the boiler. Accordingly, I examined the economizer, and found that all the graphite had remained there, owing to the very sluggish circulation of the feed water. So, after feeding graphite between the economizer and the boilers, good results were obtained. Perhaps Mr. Sutton is feeding through the blowoff pipe, in which case all the graphite will be found in the mud drum.

E. R. PEARCE.

Rochdale, Eng.

Orsat vs. CO_2 Recorder

Recent discussion in the columns of POWER as to the relative merits of the CO_2 recorder and Orsat have brought forth various expressions of opinion as to the faults and failings of the two devices. Since both the recorder and the Orsat have a proper field of usefulness in the modern boiler room, I have no desire to take either side in the controversy but wish to comment on a letter by Walter C. Edge in the issue of Sept. 16, 1913.

Mr. Edge states in his second paragraph that "an engineer after a number of tests can tell whether any serious amount of CO is contained in the sample by the percentage of CO_2, provided that the furnace is normal and is worked under normal conditions. One can keep 14 per cent. or less CO_2 and be safe as far as CO is concerned."

Unfortunately, no detailed instructions are given for ascertaining the presence of "any serious amount of CO" from the CO_2 indication. Furthermore, "normal" fur-

nace conditions which are mentioned as a prerequisite to this determination are not defined.

The last statement quoted to the effect that 14 per cent. CO_2 indicates a safe working condition I must take exception to. In the absence of any definite knowledge of the amount of CO, 14 per cent. CO_2 is undoubtedly a reasonable figure to use, but an Orsat may reveal the fact that 15 per cent. in some given case is the proper standard to work to. This, if attained, would mean a considerable saving in fuel over the results if Mr. Edge's rule is followed. In other cases it would not be safe to work to as much as 14 per cent. as a standard.

It would be a simple matter for anyone who has done much work with the Orsat to submit in detail analyses of flue gases which show results entirely disproving the general statement made by Mr. Edge. From my own experience I should only feel justified in saying that, in the average case with fairly good boiler operation, CO in greater or less amounts is apt to be present when the percentage of CO_2 exceeds 14 per cent., but as CO is in no sense proportional to CO_2 it is frequently present in large amounts with CO_2 much under the 14 per cent. specified.

H. S. Vassar.

Newark, N. J.

Value of Engineers' Services

In the issue for Aug. 19, page 272, is an editorial that is full of "meat," entitled, "One-Sided Development." I have read this, re-read it and then read it again.

It occurs to me that you have broached a phase of the situation that may be deeper than you thought when you wrote the editorial. It would seem to have its answer in the fundamental conception as to what constitutes an engineer. If an engineer be merely an engine runner, the first page of your Sept. 9 issue would seem to settle the matter by classing him as a "greaser" and of small value. If an engineer is more than a mere engine runner, what is he?

You say, "No wonder he is underpaid, which means simply that he has not, as a rule, acquired the business ability needed to sell his own services at a price which represents his real value." Now, does not this very one-sided development referred to, which prevents him from accurately estimating his value to his employer, also seriously depreciate the very value he is seeking to estimate the amount of? If his development is so one-sided that he has no accurate measure of its value, isn't it also so one-sided that he cannot accurately estimate other values in the plant under his control?

This raises another rather pertinent question, viz., What is an engineer for? If he is only to run the engine and keep it in good repair he is merely an engine runner and it would seem should not be termed an engineer at all. As such he does not earn a great deal because this is work that is relatively simple. If, on the other hand, he is a business economist in charge of the power plant, with sufficient skill to know when his plant equipment is functioning properly and at the greatest efficiency which it is capable of delivering and of keeping it in this condition without undue expense for repairs, then he will, I believe, be able to accurately estimate the value of his services to the concern employing him and will be able to show them what he is earning in such terms that he will receive it.

I do not attempt to answer your question, but wish to ask some further ones: Does not the lack of commercial instinct which prevents an engineer from marketing his services to good advantage also seriously impair his value as an engineer? Or, if he have not this faculty, or training, for estimating relative values, is he an engineer at all? Isn't he merely an engine runner or perhaps a greaser, and as such, would it not stand him in better? And again, do you not believe that frequently, when he has gained this ability to accurately estimate values (that of his own services included) he will be greatly surprised and chagrined to find that his services really had such small value?

R. L. Ellis.

Philadelphia, Penn.

Fastening Loose Babbitt

In regard to the method used by Mr. Kopple to fasten loose babbitt in a bearing shell, I do not approve of the method of using screws as he shows. These countersunk screws are made of hard metal and have a very sharp edge. They may be set well below the surface of the babbitt but are liable to work out, break off, or the babbitt may become worn down in time so that the shaft will bear on the heads of these screws, and the shaft will be scored by them.

The proper way to cure a loose babbitt lining is by re-babbitting the shells, but as this requires considerable time and is expensive, the old babbitt may be fastened and used a long time before re-babbitting is necessary. I have done this by drilling and tapping the holes as Mr. Kopple did, but instead of using steel screws I use either copper or brass rods threaded, and screwed in tight, then cut off and riveted down into the countersunk hole in the babbitt. These will remain tight, especially when the bearing warms up, and, when the babbitt wears down until they strike the shaft they will not score it as they are softer than the shaft and will wear away first.

J. C. Hawkins

Hyattsville, Md.

Abandoning Boiler in Case of Fire

Fred W. Hener, in the issue of Sept. 16, asks a question that will doubtless draw forth many ideas of what is best to do.

Here is what I advise: Close the ashpit doors, open wide the furnace doors, open the back-connection door, close the damper, put on the injector, close the main and auxiliary stop valves, and "beat it while the going is good."

There could be no explosion of furnace gases, the pop valve would take care of the steam, and the injector would soon "fill her up three gages and a smokestack" and hold the steam down, the fires meanwhile having a draft, would not furnish more steam than the pop valve could relieve, and the engineer could do no more for the boiler and should save his life before the building collapses.

R. O. Wilkie.

Miami, Fla.

INQUIRIES OF GENERAL INTEREST

Flywheel Function—What is the office of a flywheel?

J. E. S.

To store up the energy of the piston in those parts of the troke where the energy developed is in excess of the average, nd to restore it to those parts of the stroke where it is less han the average, thereby carrying the engine over its dead enters and making a near approach to a uniform rate of otation of the crankshaft.

Piston Displacement—How is the displacement of an engine determined?

J. E. S.

The displacement of an engine is the volume swept through y the piston, consisting per stroke, of the number of cubic nches of volume obtained by multiplying the area of the iston in square inches by the stroke in inches.

Displacement in cubic feet would be the displacement in ubic inches divided by 1728. Displacement per minute would e the displacement per stroke multiplied by the number of trokes per minute.

Effect of Caustic Soda on Lubricating Oil—We filter and se again the lubricating oil from an oil engine in which austic soda has been fed through the lubricators to prevent um and carbon accumulating on the pistons and rings. What will be the effect of the caustic soda on the lubricating il and the bearings?

E. C. S.

The caustic soda would not injure the bearings directly, e., by any chemical action, but by cutting the oil would reuce its lubricating quality, preventing the pores of the bearng surfaces from being filled and glazed over, thereby causng more friction and more rapid wearing away of the bearng surfaces.

Pump Horsepower—How is the horsepower of pump equired to deliver a given quantity of water against a given ead determined?

K. W. A.

The weight of water pumped per minute multiplied by the ead gives the foot-pounds of work done in one minute and his divided by 33,000 gives the net horsepower. The latter ivided by the efficiency of the pump will give the power required to be put into the pump by the motor, waterwheel or hatever source of power drives it. Usually, for a directcting steam pump, the efficiency includes that of the steam nd so that the net horsepower divided by the efficiency gives he indicated horsepower required.

Over-Stroke—What is "over-stroke," what causes it and ow is it remedied?

C. W. B.

The term "over-stroke" is most commonly applied to a oo long stroke of a pump piston. An engine piston may ake an over-stroke from the lost motion of the crankpin nd the crosshead pin or their brasses, to remedy which the earings should be taken up and the length of the piston rod roperly adjusted. The over-stroke of a pump is the reerse of "short-stroke" and is to be remedied by adjusting ne valve motion, the method depending on the style of pump. n a duplex steam pump with slide valves the pump is to be eversed earlier in the stroke, either by moving the "spool" n the piston rod, which will lengthen the stroke toward one nd and shorten it toward the other, or by adjusting the tapet nut on the valve rod to open the valve earlier in the roke.

Ammonia Condensers—Is not the atmospheric ammonia ondenser in which the ammonia gas enters at the top and ne liquid leaves at the bottom the most inefficient in use oday?

R. H. R.

It is hardly fair to call the open-air condensers with topas inlet the most inefficient type, for they give better reults than most of the submerged condensers usually used. he disadvantage of these condensers is that to take out the ensible heat of the ammonia vapor, the coldest condensing ater is used, and liquefaction takes place at a point where the water already has been heated several degrees. A further disadvantage of these condensers is that the liquid ammonia leaves where the condensing water flows from the apparatus, so that the final result is a higher condensing pressure and a higher final liquid temperature than is obtained in purely counter-current condensers.

Increasing Engine Speed—What change can be made to a fly-ball governor to increase the engine speed from 95 to 115 r.p.m. where there is no room to add more weights to the governor?

E. H.

An increase of speed from 95 to 115 r.p.m. would be 25 per cent. Before making such an increase, the builders of the engine should be consulted to learn if it is safe. An engine can be speeded up by making the governor run slower by increasing the size of the pulley on the governor or by reducing the size of the governor driving pulley on the main shaft. It is usual to build up the pulley with a lagging of leather, but for the increase of speed here contemplated the ordinary double-flange pulley on the governor would undoubtedly have to be replaced by a new pulley of larger diameter, as the lagging required on the old pulley to make it sufficient in diameter would not leave the necessary depth of flanges.

Boyle's Law—With reference to compressed air what is the meaning of $pv = 26{,}200$ ft.-lb. for 1 lb. of air as per Boyle's law?

J. M.

According to Boyle's or Mariotte's law, the volume of a gas diminishes in the same ratio that the pressure upon it is increased, if the temperature is unchanged. This law is found very nearly true for air and other gases. If p = pressure at a volume v and p_1 = pressure at a volume v_1 then $p_1v_1 = pv$; so that pv = a constant. p = intensity of pressure (absolute), and for air computations is usually in pounds per square foot, while gage pressures are given in pounds per square inch, so that p = (gage pressure + atmospheric pressure in pounds per square inch) $\times$ 144. v = volume, is usually assumed in cubic feet.

One pound of air at 32 deg. F. and under a barometric pressure of 29.92 in. of mercury (= 14.6963 lb. per sq.in. abs., or 2116.3 lb. per sq.ft.) has a volume of 12.387 cu.ft. So that for a pound of air its absolute pressure in pounds per square foot $\times$ its volume in cubic feet (or pv) = $2116.3 \times 12.387 = 26{,}214.6$ and the value 26,214 is usually taken rather than 26,200.

The product of $p \cdot v$ will always equal 26,214 ft.-lb. per pound of air at 32 deg. F. no matter what value may be assumed for p or for v.

Condensing Water for Ice Plant—For a can system compression ice-making plant with an atmospheric ammonia condenser, how many gallons per minute of 66-deg. condensing water will be required when making 100 tons of ice per 24 hr.? What would be the probable final temperature of the water?

R. H. R.

The quantity of water is difficult to estimate without knowing the exact local conditions under which the plant has to operate. For minimum steam consumption, which is really more important, as it directly affects the fuel consumption of the plant, it has been found that, for a simple Corliss engine operating a refrigerating machine, and a standard, duplex, direct-acting steam pump furnishing the water for the plant, the minimum steam consumption will be secured when about 1.7 gal. of water is showered on the condensers per minute per ton of actual refrigeration. Figuring, therefore, that 100×1.5 tons actual refrigeration will have to be done to manufacture 100 tons of ice, a total of 255 gal. of 60-deg. water per min. will be required. Under ordinary conditions of operation, there will be rejected, from the ammonia condensers 250 B.t.u. per min. per ton of refrigeration, which on a basis of 1.7 gal. of water per min. would represent a rise of about 17.6 deg. F., so that the final temperature of the condensing water, disregarding heat absorption by the atmosphere, would be 83.6 deg.

ENGINEERS' STUDY COURSE

Feed-Water Treatment—II

Calcium Sulphate

The chemical formula for calcium sulphate is $CaSO_4$. All the elements in this compound are familiar to the readers of this department so it is only the compound itself that need be studied. One of the common substances composed of calcium sulphate is plaster of paris. Unlike the carbonates, calcium sulphate does not require CO_2 to assist it to dissolve. Pure water will take just as much as water heavily charged with CO_2. A fact that is very important to the engineer is that calcium sulphate is more soluble in cool water than in hot. According to some authorities the temperature at which the most calcium sulphate can be dissolved in a given quantity of water is about 90 deg. F. As the temperature increases the solubility of this compound gradually decreases until at 302 deg. it is practically insoluble. Because of this characteristic and the fact that the scale it forms is very hard and has great cementing powers over other substances, calcium sulphate is a troublesome and dangerous impurity. Usually it can be fought only with suitable chemical compounds.

Magnesium Sulphate

The fourth and last impurity we are going to consider is magnesium sulphate, although as was stated last week there are several others that are sometimes encountered. The chemical formula for this compound is $MgSO_4$ which, as the name indicates, is the same as that for calcium sulphate except that magnesium takes the place of the calcium. And, like the other sulphate, it dissolves more easily in cool water than in hot. At 302 deg. it precipitates or deposits as a monohydrated salt, the formula being $MgSO_4H_2O$. It will be noted that the elements composing water (H_2O) have been added. This fact is indicated in the name by the word monohydrated, mono meaning one and hydrated meaning watered. As used, the word means that one molecule of water has been added to or joined with each molecule of magnesium sulphate.

By itself magnesium sulphate does not really form a scale but its presence in feed water is undesirable because it interferes with the treatment of the impurities that do form scale.

Methods of Treatment

Water containing impurities detrimental to good boiler operation can be treated in several ways, the method to be employed depending on the nature of the impurities contained. For removing mud and sediment the water may be filtered or it may be allowed to stand and "settle" before it is fed into the boiler. For what is called temporary hardness the water may be heated to 180 deg. or more. Temporary hardness is defined as hardness which can be eliminated by heating to or nearly to the boiling point (212 deg.), and is caused by the carbonates which, it will be remembered, are precipitated by heat. Hardness can be detected and its degree estimated by the effect it has upon soap.

For permanent hardness more intense heat (to at least 302 deg.) may be applied as on a closed heater or chemicals may be employed. It is the sulphates that cause permanent hardness because mere boiling at atmospheric pressure does not eliminate them.

These two terms, temporary hardness and permanent hardness, are old names invented long ago when chemistry was not as well understood as it is today. People found that water from certain sources made soap curdle instead of producing a lather. Such water they called hard. Next, they discovered that boiling sometimes improved the water; consequently such water was said to have temporary hardness. Sometimes, however, the water was only slightly or not at all improved and such water was said to have permanent hardness.

Feed water may be treated with chemicals either outside or within the boiler, the former being preferable, because the impurities are eliminated before the water is fed to the boiler and so blowing down and cleaning are required less frequently. When treatment is administered before the water is fed it is advisable to provide chemicals for the elimination of both the carbonates and sulphates, if both are present. But when treatment is administered after the water is fed only a chemical for the sulphates is required, because the heat takes care of the carbonates.

Treatment for Carbonates

Calcium carbonate can be precipitated before the water is fed to the boiler by adding to it the proper quantity of lime, slaked lime or caustic soda.

The chemical formula for lime is CaO and that for slaked lime is CaO_2H_2, and when either of these is put into water containing calcium carbonate (in the form of calcium bicarbonate, due to the presence of CO_2) a chemical reaction takes place in which the calcium of the lime joins the calcium, carbon and oxygen of the bicarbonate, producing two parts of calcium carbonate and the hydrogen of the bicarbonate joins the oxygen and hydrogen of the slacked lime producing two parts of water. The equation is

$$CaH_2(CO_3)_2 + CaO_2H_2 = 2\,CaCO_3 + 2\,H_2O$$

The calcium carbonate, being insoluble, drops out or is precipitated.

The chemical formula for caustic soda, whose chemical name is sodium hydrate, is $NaOH$. If this is put into the water instead of the lime, part of the carbon and oxygen of the calcium bicarbonate combines with it to form sodium carbonate (Na_2CO_3) which is easily soluble in water. The calcium bicarbonate being robbed of part of its carbon and oxygen changes back to calcium carbonate and, being insoluble, it precipitates as before.

The treatment for magnesium carbonate is exactly the same as for the calcium carbonate.

Treatment of Sulphates

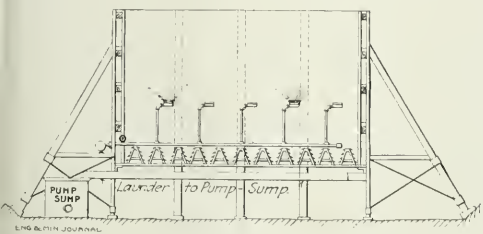
Calcium sulphate ($CaSO_4$) can be precipitated by means of sodium carbonate, or soda ash as it is called commercially. The chemical formula for the latter is Na_2CO_3. When this compound is put into water containing calcium sulphate the sulphur and one-quarter of the oxygen in the calcium sulphate change places with the carbon in the sodium carbonate, producing sodium sulphate and calcium carbonate. The first of these is soluble and harmless and the second, being insoluble, precipitates as before.

The treatment for magnesium sulphate is exactly the same as for calcium sulphate.

⁂

Spray Cooling Tower

The accompanying drawing shows the cross-section of a cooling tower in use at the South Mine, Broken Hill, Australia. It is designed on rather novel lines, the water to be cooled being admitted in the form of a spray, as shown, so that most of the contact between water and cooling air occurs while the water is suspended in a finely divided state, instead of while it trickles over inclined surfaces and drops from their edges, as in the ordinary



Section of Cooling Tower Using Spray System

type of cooling tower. The tower has inclosed sides and admits the cooling air through the bottom. The bottom itself consists of a series of launders into which the water is conducted by louvered frames. By means of transverse launders, the cooled water is conducted to the boiler pump.

Excellent results have been obtained from this type of cooling tower, attributable to the following conditions: (1) The air has a large and unrestricted inlet to the tower through the bottom only; (2) the sprayed water affects an equal supply of air in all parts of the tower; (3) the air and the vapor outlet is not contracted at the top and, therefore, there is a minimum restriction to the passage of the air, (4) the air is not retarded in its upward passage by the apparatus which is used to distribute the water.

As illustrated, the tower draws in the air by natural draft, but if desired it may be built lower and the draft furnished by wind shields disposed about the lower portion below the launders and louvers.—*The Engineering and Mining Journal.*

⁂

A Steel Chimney to increase the height of an existing brick chimney has been put in place on the Borland Building, Chicago. The steel extension is about 100 ft. high and 9 ft. diameter. It was raised in one piece to the top of the building and set in place on the brick chimney by a derrick having a spliced beam about 140 ft. long.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Hey, feller, as an engineer, let us ask you what in thunderation becomes of your hard-earned money? Here's a highforehead declaring that "we are wasting six hundred million dollars yearly." Now you just buck up, and don't let folks know your business.

⁂

"Safety first" is the Pennsylvania Railroad's slogan. As this road employs 210,000 men and carries 150,000,000 passengers yearly, it's in a fair way to test out such a slogan. Other roads please copy.

⁂

Here's another instance where we can't get what we're worth. Your per capita wealth as an American is just $1360. A few simps, on learning this, went to Washington to get theirs. And they got it—not.

⁂

A bit of optimism from the "Coal Trade Bulletin": "If it isn't cars, it's labor. If it isn't labor, it's floods. If it isn't floods, it's drought. Any way you look at it, the coal man is bound to catch hades. Lately it has been all four. And yet he manages to wear a smile."

⁂

Electric vehicles have driven many of the old Dobbins into the discard. And now Turk and Golden, those patient old farm standbys, will soon have their usefulness limited to material for oxtail soup. Gasoline engines are doing it. At that, neither gasoline nor electricity makes good soup.

⁂

The banana, contends the Hon. John Barrett, has brought peace, prosperity and health to the Central American republic. Most everything has its good side, but personally, having slipped on a few, we are at odds with the outside of the banana.

⁂

A fourteen-page discussion by Arthur Williams and the Electric Vehicle Association of America appears in "The Central Station" for October. Having counted 2769 "I's," 9431 "my's" and 7645 "me's," we gave it up. We'll wait until T. R. returns from South America.

⁂

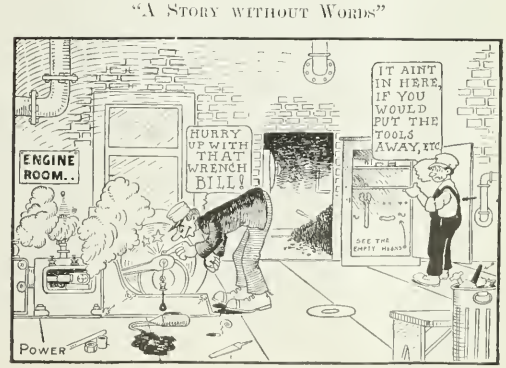
Most affecting was the "Electrical World's" heart sob over "the inspiring picture" drawn by Samuel Insull for the energy supply service which is now on display for those having "the general welfare of humanity at heart. It is the central-station man's ideal to furnish ALL the energy in a community". Sounds like one of those "ideals" that gobbles everything in sight—when that brand of idealist can get away with it.

⁂

"Terpezone" is the newest consumption cure. It's a "breathable gas," combining ozone and pinine, the essence of turpentine. So much "gas" has heretofore been expended on corraling the gullible, we hope this cure is going to stick.

⁂

"A Story Without Words"



Boiler Attachments—III

By J. E. Terman

SYNOPSIS—A treatment of how and how not to connect the feed-water pipe to a boiler. The advantages and disadvantages of the automatic feed-water regulator and high-and-low water alarm are also discussed.

It is not such an important matter as to where a feed pipe enters a boiler, as it is where the feed water is discharged. On account of the accessibility for making connections, the horizontal-return tubular type of boiler is usually arranged to receive the feed pipe through the front head immediately above the tubes, or through the top of the shell. Most boilers of this type are equipped with some form of internal feed pipe, which acts as a heating device, tending to bring the water up to the temperature of that in the boiler, before it is brought in contact with any part of the boiler.

To make a suitable connection at the entrance point, a steel or composition bushing should be used, which is threaded externally to screw into the hole tapped in the boiler head or in the pad placed on top of the shell.

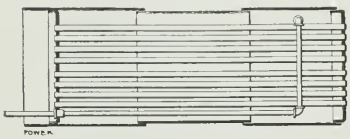


Fig. 15. Internal Feed Pipe

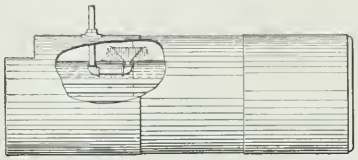


Fig. 16. Steam-Space Feed

Two Ways of Introducing Feed Water

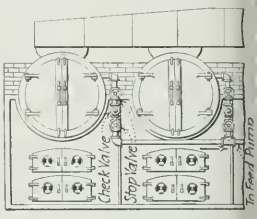


Fig. 17. Feed-Pipe Valves for Two Boilers

This bushing should also be threaded internally at both ends, to connect the inside and external portions of the feed pipe. To avoid the expense of this bushing, it is sometimes customary to place a running thread of sufficient length on the end of the external portion of the pipe, so that it may be screwed through the head far enough to allow of attaching the inner portion of the pipe to its end. This arrangement is not satisfactory, and the use of a bushing should be insisted upon for all boilers equipped with an internal feed pipe. A common arrangement for the internal portion of the pipe for a horizontal, return-tubular boiler, is shown in the plan view, Fig. 15, where the pipe runs the entire length of the boiler and crosses over and is discharged between the tubes and the shell, near the rear head on the opposite side.

It is necessary that the internal portion of the feed pipe be hung securely from the shell or braces, and not allowed to touch the tubes or shell. Unless this precaution is taken, it is likely that a hole will be produced in the boiler at any point on which the pipe may rest, because, the pulsations of the feed pump cause it to constantly vibrate, which keeps the metal surfaces clean at the point of contact. Under these conditions, corrosive action of the feed water, which under ordinary conditions could not be noted, will destroy the metal with extreme rapidity. The speed with which corrosion acts under these conditions can only be appreciated after an experience or two.

One of the best feed arrangements for horizontal, return-tubular boilers is a steam-space feed, as illustrated in Fig. 16. This feed, if properly arranged, discharges the water through the steam space in a finely divided state, and it is heated practically to boiler temperature before it can come in contact with any of the metal parts of the boiler. This sudden heating, while the water is not in contact with any surface, tends to bring down a considerable portion of the scale forming matter in a granular form that can be readily washed out of the boiler. When discharging the feed water in the steam space of the boiler, to avoid a water-hammer, the pipes must be kept constantly filled with water. If the feed pipe comes from above, as illustrated in Fig. 16, a substantial trap or pocket must be formed below the outlet.

The general instructions in regard to feeding a boiler are that the feed pipe should be located so that the water will be discharged at the coldest point. This rule is often in error, and the writer believes could be replaced with, "locate the discharge so that the incoming feed water must mingle thoroughly with the water in the boiler, before it comes in contact with any part of the boiler that is likely to be injured by sudden temperature changes."

A method of feeding horizontal, return-tubular boilers that is fairly common, but which should never be used, is to attach the feed to the blowoff connection. This point of attachment is probably chosen, because it reduces the number of connections to the boiler by one, and also, because it saves some pipe and fittings. This method of feeding is severe on the boiler shell and is likely to produce cracks or leaking at the girth seams along the bottom of the shell, unless the boiler is of the very best construction.

The small vertical tubular boiler is best fed through the shell about one-half the tube length above the crown sheet. For large boilers of this type, it is best to use an internal feed pipe and discharge the feed water near the center of the nest of tubes. Sometimes the internal pipe is slotted or perforated, so that the feed is discharged across the entire diameter of the boiler. It is common practice to feed small portable boilers of this type in the water leg at a point about even with the top of the bed of fuel; this should always be avoided, as

t produces severe strains in the furnace sheet opposite he feed inlet and it is likely to produce cracking of the heet or leakage around the stay-bolts.

With the locomotive type of boiler used for stationary work, a good point to discharge the feed water would be near the top of the tubes and about three feet forward from the tube sheet, but it is rarely put in at this point, because the average boiler of this type can not be entered above the tubes. The usual method is to discharge the feed in the water leg below the shell. The objection to locating the feed at this point is the same as for the water leg of the vertical tubular type of boiler.

The best readily accessible point for the attachment of the feed pipe in the locomotive type of boiler is in the shell below the waterline and near the front head. The location of the feed pipes on water-tube boilers has generally been decided by competent designers, and they are usually placed in the most suitable location.

Feed Valves

The feed valve is the most frequently manipulated valve on a boiler, and for that reason it should be easily accessible. If the plant is of such size that the fireman's duty is to watch the water level in the boilers the feed valves should be located at the front of the setting and within easy reach of the floor. A common and convenient arrangement for the feed pipes of horizontal, return-tubular boilers, set in a battery, is illustrated in Fig. 17.

It is best to use two stop valves on a feed line and locate the check valve between them. Then it is possible to remove any obstruction that may pass through the pipe and lodge in the check valve, without necessitating a shutdown or the stoppage of the feed to the balance of the boilers. If globe valves are used for feed valves, they should be turned so that the discharge from the pump will be beneath the disk. This will prevent shutting off the supply of water from the boiler, should the disk become detached from the stem. When more important considerations do not interfere, the feed and check valves on a feed pipe should be placed as close to the point where the pipe enters the boiler as possible.

Under no consideration should the feed pipe connect two or more boilers together without the intervention of check valves, with the exception of heating plants, where the returns are fed directly to the boilers by gravity. Without check valves on such connection for power boilers, the water may be driven from one boiler to another, and cause a dangerous condition of low water to exist in some of the boilers. Fig. 18 illustrates an incorrect connection of this kind that is frequently met with in sawmills and similar plants. This is a dangerous arrangement, for under operating conditions, with the usual arrangement of steam pipes, sufficient differences of pressure may exist in the different boilers (although the steam valves are wide open) to cause a serious difference in the water level. If a main-stop valve is closed on one of the boilers without the feed valve being also closed, the water would be either forced out of this boiler, due to an increase in pressure above its mates, or it would entirely fill up by drawing water from the other boilers, should the pressure in it fall.

Automatic Feed-Water Regulators and Alarm Columns

These two devices are discussed under the same heading because they should go hand in hand and both should be looked after by a competent water-tender. It is absurd to say that all automatic devices are dangerous for use on a boiler, for a safety valve is automatic in action, yet no intelligent engineer would think of operating a boiler without its being equipped with such a safety device. It is a fact, however, that a boiler attendant after noting the repeated successful operation of an automatic device, begins to rely on its use and relaxes the watchful care he would otherwise bestow on the various devices. A possible answer to the question, Do automatic devices in a boiler plant pay? is that many of them enable an intelligent operator to handle more work with greater efficiency than could be done without their aid. They should never be used to aid a lazy or incompetent attendant to shun work.

Aside from safety valves and damper regulators, automatic feed-water regulators are the most common of the automatic devices used in connection with boiler operation. There are many kinds of feed-water regulators, all of which operate on the change of water level in the boiler, and since there must be some appreciable change in the water level, in order to sufficiently affect the buoyancy of the floats used to operate directly or indirectly the feed-controlling valves, the action is in reality intermittent and not constant.

A good illustration of the intermittent action of so called feed-water regulators, is shown in a pamphlet issued by the General Electric Co. on "Steam-Boiler Economy." A diagram showing the rate of feed entrance and steam output, taken over a period of practically an hour, shows that the feed water was admitted at a uniform rate of about 54,000 lb. per hour for an interval of three minutes, after which the feed would be automatically stopped with practically no admission for a period of nine minutes, after which another three-minute period of maximum feed flow would occur. No figures are given for the feed-water temperature, but the output from the boiler was decreased from a rate of about 24,000 lbs. of steam per hour as a maximum to 8000 lb. per hour. This drop in steam output occurred through a period of three minutes and lagged about one and a half minutes behind the feed period. After the lower limit was reached, the steam output increased at a uniform rate to the maximum. It can be seen from this data that such a regulator operating on a single boiler plant, if the plant was worked near its maximum capacity, might be a source of trouble instead of an aid to uniform operating conditions. If this kind of feed apparatus should operate in synchronism on several boilers, it would affect the ability of the plant to care for overloads.

The reduction of boiler capacity due to intermittent feeding has probably not been thoroughly appreciated by the average engineer, but the fireman has always known what a help it was to have the feed cut off while he was making a fight to gain on the steam pressure. It is probable that with a load that is at all steady, the best operating conditions are obtained by using a hand-controlled valve which bypasses the regulator, this valve to be so set that it will not quite supply the boiler with

the average amount of feed water required and allow the automatic valve to care for the deficiency. This arrangement will greatly lengthen the time intervals between the operations of the automatic valve, and consequently reduce the effect of its operation on the boiler performance. One regulator manufacturer has recently gotten out a regulator valve with such a bypass as part of the valve proper.

The absurdity of the claim made for the average feed-water regulator, that the apparatus maintains a continuous feed, can be readily appreciated when it is considered that the drop in water level of, say, a 250-hp. water-tube boiler (without the introduction of feed water) is only 0.15 in. per minute when operating at rating. A 100-hp., horizontal, tubular-boiler would change the water-line about 0.12 in. per minute, under the same conditions.

In installing a feed-water regulator the portion that contains the actuating float is placed near the boiler on a line with the proper water level in the boiler, and the feed pump is usually equipped with an automatic governor, which controls its action according to the pressure a float which operates a whistle to notify the attendant when the water level is too low. Alarm columns are usually made to notify the attendant when both high and low levels of water are reached, but the writer believes that it is much safer to limit the indications to low water only, for then there can be no mistaking what is the trouble when the whiste blows and the attendant is not required to make any distinction between tones. A number of accidents, particularly on vertical boilers, where the water columns could not be readily seen from the floor level, have been caused by the attendants blowing down a boiler, to relieve a condition of supposed high-water level, when he was in reality further emptying a boiler in which the water was already low. The only way to insure the satisfactory operation of automatic apparatus, is to be ever on the alert to discover any derangement, and this requires that its operation be tested frequently and at regular intervals.

Proper Arrangement of Safety Valves

It is usually considered sufficient for all purposes of safety that a safety valve be attached to the steam space

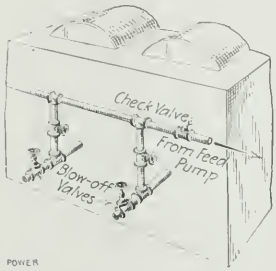


Fig. 18. Incorrect Feed-Pipe Connection

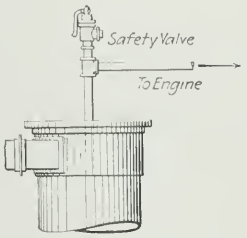


Fig. 19. Faulty Safety-Valve Piping

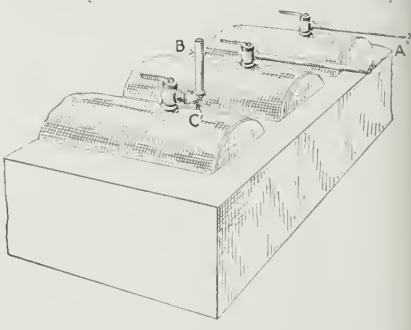


Fig. 20. Vertical and Horizontal Discharge Pipes

in the feed line. Some regulators operate so that the closing of the automatic feed valve is positive to prevent further entrance of feed water to the boiler, and no amount of pressure in the feed line will tend to cause the valve to open. With this equipment, if the pump governor fails to work from any cause and the cylinder ratios are large, a dangerously high pressure may be developed in the feed lines. The writer prefers regulators that do not close the inlet valve in this positive manner, but permit a leakage by the valve when certain differences exist between the boiler pressure and the feed-line pressure.

No feed-water regulator should be used on a boiler without a low-water alarm column being also used; and this column and its connections to the boiler should be entirely separate and distinct from those to the regulator. It is a common expedient to reduce cost by combining these different pieces of apparatus in one, but this arrangement should not appeal to the engineer, for he should realize that the complete separation of these two pieces of apparatus is the only thing that can render one a real check against the other, and such a check is most necessary.

The low-water alarm column is, of course, used in the regular way as a water column and in addition it carries

of a boiler without the intervention of a stop valve, and have the connections to the boiler and from the discharge side of the valve fully as large as the entrance port of the valve. The intelligent application of this very necessary safety appliance is, however, not such a simple matter. In the first place if a spring-pop valve is used, it is generally adjusted to be fairly sensitive; that is, it will perform all of its functions within a small range of pressure. On this account, when possible, a safety valve should be placed on a separate connection and not on the main steam outlet. If a boiler is only provided with one steam outlet, then the safety valve should be located as close to this outlet as possible.

When steam is used to operate a reciprocating engine, it is drawn from the boilers in puffs, instead of a steady stream, and under these circumstances variations in the pressure are constantly occurring in the pipe line. The variations in pressure are much more pronounced near the engine and less so near the boiler. Where a pop valve is located on a pipe line, away from the boiler, under these conditions, and the running pressure is near that for which the valve is set, the valve is liable to chatter and wear out the disk or seat in a short time. Fig. 19 shows an arrangement of this kind on a vertical boiler that gave trouble from this cause. The tee in this

case offers about the same resistance to the passage of steam as would be caused by 40 ft. of straight pipe and the variations in the pressure under the valve, due to the uneven draft by the engine, was sufficient to cause it to chatter badly whenever the steam pressure reached a point near that at which the valve was set. The flow of steam in a pipe leading to a safety valve and also in the connection leading from the exhaust side, can cause considerable pressure changes at the valve during its operation, and if these connections are too long or small they may prevent it working satisfactorily.

It is annoying, in the average plant, to have the valves discharge directly in the boiler room, so escape pipes are generally used to carry the steam outside. When it is possible the escape pipes should be placed in a horizontal position, as shown at *A*, Fig. 20, with a slight fall from the valves to the open end, so that there will be no tendency for water to collect in these pipes. It is not practical to have horizontal discharge connections in all cases and sometimes these pipes are run through the roof.

It is evident that care must be taken with such an arrangement, to prevent the collection of water in the discharge pipes. Nearly all pop safety valves have a small hole provided in them for this purpose, but they are usually too small to be trusted, and a 1-in. hole should be drilled in the bottom of each elbow at *C*, and even with a hole of this size it is necessary to watch it to prevent its becoming stopped with rust and scale. When the discharge pipe is not positively drained and water collects in it, the spring of the valve is ruined in a short time and the disk is liable to corrode fast to the seat, or scale may block the free space between the coils of the spring so that it is entirely inoperative; this condition is found with alarming frequency by boiler inspectors.

To insure that a safety valve is operative, its freedom of action should be tested daily by raising the steam pressure until the popping point is reached, but often this method of testing is objectionable, for some reason, and the valve must be tested by hand; to test by this this method, the testing levers should be kept in place at all times and not left detached, as is frequently the case after setting a valve. When the roof over the boilers is low, it is generally a hot, dirty place for the engineer to crawl to test the safety valves and on this account it is often neglected. A chain or rope, with suitable pulleys may be arranged so as to test the freedom of the safety valves from the floor level, but in putting up such a contrivance, every precaution should be taken to see that it will be impossible for it to in any way hinder the regular operation of the valve, particularly so, if it happens to be of the lever type.

The safety valves on all boilers connected to a common steam main should be set at approximately the same pressure, and this should be the pressure suited for the weakest boiler in the battery. Where boilers are capable of carrying varying pressures and the valves are not all set at the lowest pressure, the steam pressure may rise above that suitable for the weakest boiler in the event of the sudden stoppage of the flow of steam, because the valve area for the relief of steam at the low pressure would be inadequate.

The setting of a pop safety valve should never be changed without knowing for what pressure the spring was originally intended. A description of the spring, giving the inside or outside diameter of the coil, and with accurate dimensions of the cross section of the bar from which the spring was made, together with the length of spring and size of valve, if sent to the manufacturer of the valve, will bring forth the needed information. The danger of setting a pop valve without knowing for what pressure the spring was originally intended to be used, is that the spring may be too weak for the pressure desired and the coils compressed to a point where the free liberation of steam may be interfered with, if not absolutely prevented, as has often been found to be the case where inexperienced persons have attempted to readjust pop safety valves.

If the pressure is much less than that for which the spring was designed the valve will not operate satisfactorily. Generally a safety-valve spring is suited for a 10 per cent. increase or decrease in pressure from that for which it was originally intended, but it is never safe to assume that the pressure to which a valve is set is the one for which the spring was designed.

Some Power Features of the Ghent Exposition

Three years ago there was a large international exposition at Brussels. It ought to have been in 1908 and Ghent, only an hour's ride away, was to have one this year, five years later. Notwithstanding the postponement of the Brussels show and the short interval, Ghent has persisted in her determination to have the exposition this year as intended, and under the circumstances has produced a really creditable display.

The most striking exhibit in the power line is that of Carel Frères, of Ghent, whose activity in the development of the modern Diesel engine has given them an international reputation and led to an extensive enlargement of their works. Their exhibit occupies the center of Machinery Hall, and has for its most prominent feature a 1600-hp. reversible marine engine, carrying a large propeller upon its shaft, with thrust block and mountings just as it would be installed in a vessel. It is under the complete control of the operator and always attracts a large crowd when it is maneuvered. It is two-stroke-cycle, single-acting, with six cylinders, 510 mm. (20 in.) in diameter, 920 mm. (36 in.) stroke and is designed to run at 130 r.p.m. There are two double-acting, scavenging pumps run by levers from the main engine, and the Reavell compressor for the fuel-injection air is carried at the end of the shaft opposite that to which the screw is attached. The crankshaft is made up in three duplicate lengths so that only one spare has to be carried. The injection pressure is about 45 atmospheres and the scavenging pressure between 4 and 5 lb. There are four scavenging valves in the head of each cylinder, regularly disposed about the central fuel valve, directly behind which and between two of the scavenging valves is the air-starting valve. It is claimed that about 30 per cent. less in length of the vessel is required for such an installation than for engines and boilers, and that there is besides a considerable saving in weight as compared with the steam-driven plant.

The Carel Frères have also a four-cylinder, vertical, two-stroke-cycle engine of 1000 hp. connected to an al-

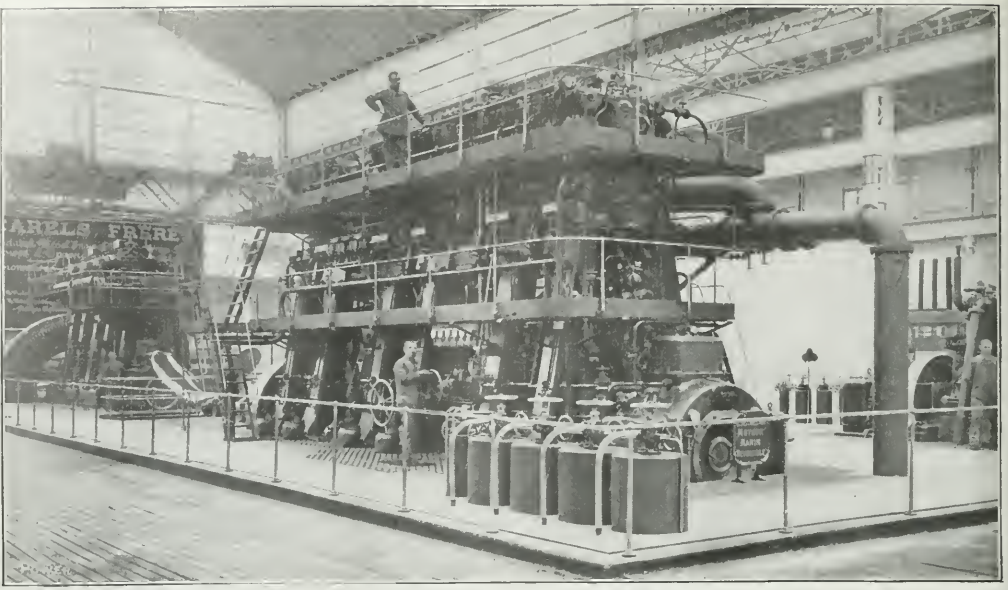


FIG. 1. TWO-STROKE-CYCLE MARINE CARELS ENGINE OF 1500 HP.

ernator furnishing current for the exposition. This runs at 160 r.p.m. and is much smaller than the marine engine in proportion to the power which it develops. It has a single scavenging pump in line with the other cylinders and operated by a crank from the main shaft, while the scavenging pumps of the marine engine are on the floor level and behind the main machine.

the four-stroke-cycle type and has a two-stage compressor operated directly from the crankshaft. They are producing a brake horsepower on about 190 grams (0.42 lb. prox.) of fuel oil per hour.

They exhibit also a 2500-hp. cross-compound steam engine, but it is a sign of the times that it is not in motion.

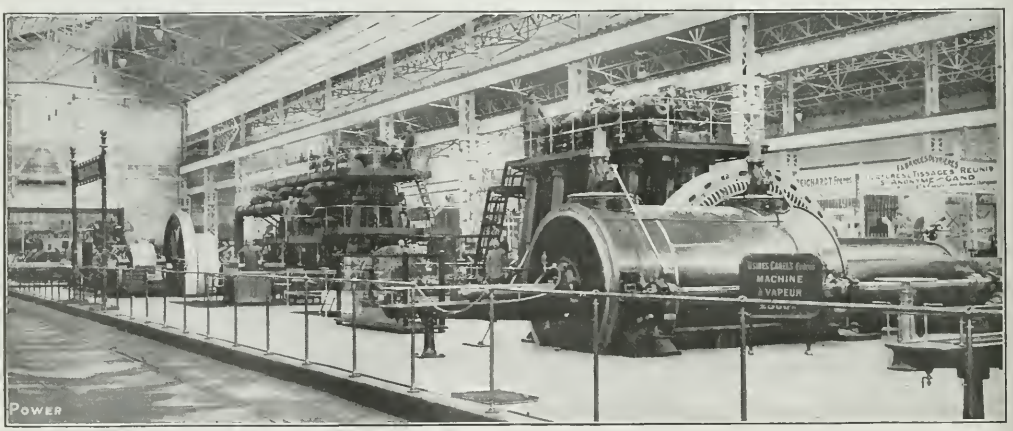


FIG. 2. GENERAL VIEW OF EXHIBIT

There is also shown an auxiliary compressor for the marine engine, two cylinders, vertical, four-stroke-cycle, 120 hp.

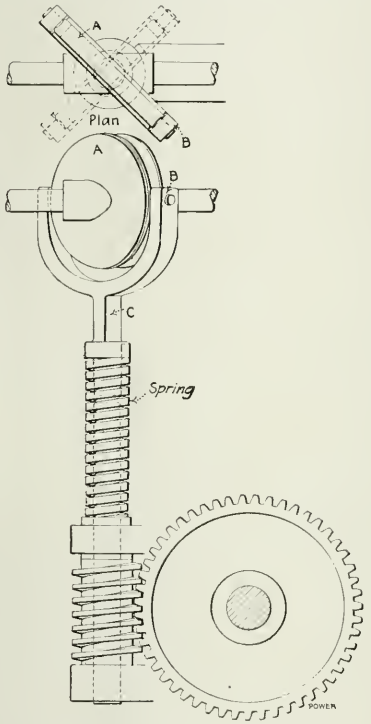
They have just developed a horizontal, single-cylinder engine, a 100-hp. example of which is shown. It is cheaper and more accessible than the vertical and the trunk piston can be taken out without removing the cylinder head by uncoupling the connecting-rod. It is of

Van den Kerchove, of Ghent, has two tandem-compound engines with his piston valves 500 hp. each at 150 r.p.m. and two Van den Kerchove-Bergmann turbines of 1500 kw., each running at 3000 revolutions. They have one Curtis wheel with two velocity stages and 10 Rateau or pressure stages. They are sold to the city of Ghent for its central station and help to supply current for the exposition.

An impressive exhibit is a Curtis runner for a turbine, some seven or eight feet in diameter and bearing the legend: "Capable of developing all by itself 3000 hp. at 1500 r.p.m." Its significance comes from its juxtaposition to the comparatively massive and complicated Diesel which develops only half as much. But the boilers and auxiliaries are not exhibited with the wheel.

An installation of Balcke or Le Blanc condensers is shown running in an open tiled condenser pit.

Brown, Boveri & Co. have a 2000-kw. unit running at 3000 r.p.m. and a smaller unit not in operation. They show also a surface condenser, one side of which may be opened and cleaned while the other side is in use.



Actuating Device for Chain Grate

Cockerill, of Seraing, shows a crankshaft weighing 85,000 kg. (187,000 lb.), 45,000 of which is shaft and 40,000 cranks.

The Société de la Meuse exhibit a turbine of 1250 kw. designed to run at 3000 revolutions.

There are a few small locomobiles, by French and Belgian makers, one in particular by Boulte, Larbodiere & Cie., Aubervilliers (Seine), is hardly a locomobile but with a vertical engine combined with a vertical boiler, superheater, etc., upon the same base.

Delaunay Belleville exhibits a boiler with an interesting mechanical stoker. Imagine the pulley *A* mounted obliquely on its shaft. As the shaft revolves the pulley will vibrate between the solid and the dotted positions. The pulley carries a ring *B* with pins to which is fitted the forked end of the shaft which operates the worm gear of a chain grate. This shaft is rotated backward and forward by the vibratory motion of the pins and carries at its lower end a spring incircling the shaft which carries the worm. As the shaft *C* turns in one direction it wraps the spring tightly around the worm shaft and carries it forward, while on the backward movement it tends to unwind and loosen the spring which slips backward around the shaft without turning it.

The largest transformers in the world are being built by the Siemens-Schuckert Co., at Nürnberg, for the Uberland central station, near Essen, Prussia. They are two in number of 24,000 kw. capacity, each 6300 volts primary, 25,200 secondary.

Purchasing Coal under Specifications*

By George S. Pope†

In purchasing coal for any power plant the aim should be to obtain a fuel which, all things considered (such as equipment, price of coal, and cost of labor and repairs), will produce a horsepower for the least cost.

The purchase of coal by the government under specifications depending on the heating value of the coal, its content of ash and of moisture, and other considerations, rather than upon the reputation or trade name of the coal, was first adopted by the United States Treasury Department in 1906. Since then the plan, variously modified in form, but the same in principle, has been gradually adopted by other departments until at present, of the coal used by the government, the total value of which approximates $8,000,000 annually, more than half is purchased under specifications.

Summary of Advantages

The advantages of purchasing coal under specifications may be briefly summarized as follows:

1. Bidders are placed on a strictly competitive basis as regards quality as well as price. This simplifies the selection of the most desirable bid and minimizes controversy and criticism in making awards.

2. The field for both the purchaser and the dealers is broadened, as trade names are ignored and comparatively unknown coals offered by responsible bidders may be accepted without detriment to the purchaser.

3. The purchaser is insured against the delivery of poor and dirty coal, and is saved from disputes arising from condemnation based on the usual visual inspection.

4. Experience with the old form of contract shows that it is not always expedient to reject poor coal, because of the difficulty, delay and cost of removal. Under the present system, rejectable coal may be accepted at a greatly reduced price.

5. A definite basis for the cancellation of the contract is provided.

6. The constant inspection and analysis of the coal delivered furnishes a check on the practical results obtained in burning the coal.

7. Payment in proportion to quality incites the contractor to prepare the coal more carefully.

*Abstract of a paper read before the National Association of Cotton Manufacturers, at the 95th semiannual meeting, Atlantic City, N. J., Oct. 2, 1913.

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Award of Contracts

In the purchase of coal according to its heating value and composition an important detail, which seems not to be thoroughly understood, is the manner of making awards. Awards should not be made solely on the chemical analyses and the heating value determinations in the absence of information of the behavior of the coals in practical service operation, for while calorific rating allows an award to be made to the best economic advantage, other factors may, under certain conditions, have considerable weight, especially if uncertainty exists as to the suitability or adaptability of an untried coal to the plant for which it is purchased, and the consideration of this question must take into account the type and condition of furnaces and grates, the draft, the labor of handling coal and ash, the storage facilities, etc.

Two coals having the same percentage of ash by analysis may behave very differently in the furnaces, for one may clinker and the other not, the ash by analysis not indicating the extent to which the ash may fuse or slag on the grate bars and thus seriously interfere with the capacity and efficiency of the plant. The relation of the composition of the ash to its liability to clinker is a matter which is being studied, but as yet altogether satisfactory results have not been obtained. On the other hand, clinkering is frequently caused by the firemen slicing the fire too often and working the ash up from the grates into the hot coal bed, where it melts and fuses into heavy dense masses.

The chemical analysis of coal may not indicate whether the coal will cake in the furnace, thereby interfering with the draft and lowering the rate and completeness of combustion.

Different coals with the same percentage of volatile matter may not behave alike in the furnace because the proportion of combustible and noncombustible constituents in the volatile matter, the character of the combustible constituents, and the temperature at which they are given off in the furnace, vary in different coals.

In the absence then of information on the results which may be obtained in actual service to supplement the chemical analyses and heating tests, it may prove difficult to determine the award to the best economic advantage and service tests in the plant equipment will be required.

In comparing bids on the basis of the chemical analyses and B.t.u. of the coal offered by the respective bidders, the method used is to merge the variables—ash, moisture, calorific value and price bid per ton—into one figure, the cost of 1,000,000 B.t.u. Any coals which have proved from experience or by practical test unsuited for the furnace and boiler equipment, or have failed to meet the requirements of the city smoke ordinances, may be eliminated from consideration regardless of their calculated costs per million B.t.u. and the remaining bids may be compared. The lowest bid then selected should be considered as a tentative award only, the final award to depend on the coal giving satisfaction in every respect in the plant equipment and on the satisfactory fulfillment of the contract.

The relative facilities, competency and responsibility of the competing firms must, of course, also be considered in making awards.

Government Specifications for Coal

Two classes of coal, anthracite and bituminous, are recognized and differentiated in government specifications. By anthracite is meant the coal mined in Susquehanna, Lackawanna, Luzerne, Carbon, Schuylkill, Columbia, Sullivan, Northumberland and Dauphin Counties, Penn. By bituminous coal is meant varieties other than anthracite, including the several grades of semibituminous and sub-bituminous.

The bituminous specifications require the bidder to specify the quality of coal offered in terms of moisture, "as received," ash, sulphur, volatile matter and B.t.u., "dry coal"; these values becoming the standards of the contract to determine rejectable coal and the price to be paid for delivered coal.

The specifications allow a variation of 2 per cent. from the ash and heating value standards before making corrections in price. This is allowed to provide (*a*) for the reasonable variations in composition that, it is recognized, the same sample may show in the laboratory in two different determinations, (*b*) for variations that arise in preparing and reducing the gross sample collected from the delivery to a quantity convenient for transmittal to the laboratory, (*c*) for variations due to the collection of gross samples as representing the coal sampled, and (*d*) for allowing the contractor latitude in the preparation of the coal, since it is recognized that the quality of his coal as expressed in terms of ash and B.t.u. cannot be strictly controlled within narrow limits.

The specifications require the bidders to specify a maximum moisture content in the coal offered. This value becomes the standard of the contract. No price correction is made for deliveries containing by analysis a moisture content less than the standard, but the price is corrected for moisture in excess of the amount guaranteed by the contractor, the deduction being determined by multiplying the price bid by the percentage of moisture in excess of the amount guaranteed.

The fact is recognized that the amount of moisture contained in coal produced from day to day from the same mine, or group of mines working the same bed, is largely accidental, and is a matter over which the buyer and seller have only a slight control. However, in order to place a negative value on high-moisture coals and to protect the government against the delivery of coals containing excessive amounts of moisture, the bidders are required to guarantee a maximum moisture content. Price corrections on account of excessive moisture are seldom necessary if the contractor does not guarantee a content lower than can be actually maintained on an average.

No corrections in price are made for variations in volatile matter, for the government does not consider any scheme of applying penalties on account of such variations to be equitable.

The results of tests and experiments show that the percentage of sulphur does not indicate the behavior of the coal in the furnace. For a long time it was thought that the sulphur formed clinker, but investigations point to the fact that sulphur is not the only cause of clinkering; in fact, there may be no difficulty from clinker in burning coal containing as much as 5 per cent. or more sulphur. The relative proportions of iron, sulphur, lime, alumina, silica, etc., in the ash affect its fusibility, where-

as the method of firing and the rate of combustion are important factors in the formation of clinkers. At many power plants the fireman slices the fire too often and works the ash up from the grates into the hot coal bed, where it melts and fuses into heavy dense masses of clinker. At high rates of combustion the ash in a given coal may clinker (though at lower rates it does not), because of the ash being raised to the fusing temperature. Because of these variables no corrections in price for variations in sulphur are made under government specifications, but the contractors are required to specify the sulphur content so that standards for the coals to be delivered may be established.

Many commercial and municipal specifications exact penalties for a slight increase in the sulphur content, although coal of high sulphur content may clinker less and its heating value may be higher. One specification received by the Bureau of Mines exacts a deduction of 5 per cent. in price for each 1 per cent. of sulphur in excess of the standard. In the case of a coal supplied at $3 per ton, the presence of 1 per cent. of sulphur in excess of the standard, as indicated by analysis, would often result in an unwarranted deduction of 15c. a ton. Under such a contract, the variations which are recognized to exist in sampling and analysis may cause a contractor unjustly to suffer a heavy deduction.

Both the sulphur and the volatile-matter content should be used to classify coals and to identify the coal guaranteed. Variations indicating the substitution of an unsatisfactory coal should be considered cause for rejection of the coal or for cancellation of the contract.

For the purchase of the domestic sizes of anthracite coal, the government has established a standard of ash content for each size. Coal containing ash in excess of a maximum limit is subject to rejection and to removal by the contractor at no cost to the government, or if used it is subject to a deduction in price. B.t.u. standards are not used, as it has been determined that the heating value for the different sizes is, in the main, a function of the ash content, varying inversely and in proportion with the ash; that is to say, if the ash content is increased, for example, 1 per cent., the heating value is decreased 1 per cent.

The power-plant sizes of anthracite may be purchased either under the specifications which are used for bituminous coal, the bidder guaranteeing the heating value, ash, moisture, etc., or under specifications similar to those for domestic sizes, wherein a standard of ash or B.t.u. or both is established.

Sampling

The method of taking and preparing samples for shipment to the laboratory has been given fully as much care as the making of the analyses and tests. The method employed is to select portions from all parts of a consignment or delivery of coal and to systematically reduce the gross sample, obtained by mixing these portions, to quantities that the chemist requires for making ash, and other determinations, or that can be burned conveniently in the calorimeter, an apparatus for determining the heating value. The gross sample should be so large that the chance admixture of pieces of slate, bone coal, pyrite, or other impurities in an otherwise representative sample will affect but slightly the final results. Increasing the size of the gross sample tends toward accuracy, but the possible increase is limited by the cost of collection and reduction. In reducing the gross sample by successive crushings and halvings or fractional selections, the object is to procure a small laboratory sample that, upon analysis, will show approximately the same composition as the gross sample itself, or, in fact, as the entire quantity of coal from which the gross sample was obtained.

The method of sampling is very often given scant mention in specifications and contracts, thereby leaving one of the most important features determining the successful and satisfactory application of the specification method of the purchase of coal almost wholly in the hands of the purchaser, the seller having little or no means whereby he can exercise a control of the manner and method of collecting and preparing samples that should represent the coal furnished. Because of its importance, government specifications give in considerable detail the method of sampling.

The best opportunities for procuring representative samples are afforded while the coal is being unloaded from railroad cars, ships and barges, or while it is being dumped from wagons. Samples collected from the coal exposed in piles, bins, barges or ships can be considered representative only under the condition that the mass of coal is homogeneous throughout. Such a condition is highly uncertain and even improbable, and the analysis of samples collected from the surface may give results that are very unreliable as indicating the nature of the entire quantity, and that may be worthless as a basis for determining an equitable price to be paid for the coal because when sampled in this manner errors of the personal equation factor are multiplied.

The preparation of a gross sample for shipment to the laboratory involves three operations: (1) crushing, (2) mixing and (3) reduction in quantity. The operations must proceed in stages according to a prearranged plan and in a systematic manner until a final sample of about 3 lb. is obtained. This 3-lb. sample should be placed in a container and sealed air-tight and forwarded to the laboratory for analysis.

The advantages of definite specifications for purchasing coal, the results obtained from the method, together with the analyses and tests of coals delivered under government contracts during the fiscal year 1909-10, are published in Bureau of Mines Bulletin 41, "Government Coal Purchases under Specifications." Directions for sampling and types of specifications are given in Bureau of Mines Bulletin 63, "Sampling Coal Deliveries and Types of Government Specifications for the Purchase of Coal."

Duties of the Marine Engineer—The chief engineer is held responsible for all the machinery on board. Apart from the main engines, the auxiliary machinery includes the following: Windlass gear for heaving the anchor, capstans, warping engines, winches and steering gear, refrigerating and condensing plant, air circulating, feed, fresh water, sanitary and other pumps, and miles of piping of all sizes. The electric plant alone is capable of supplying power sufficient for a town of 20,000 inhabitants. Fans supplying air to the different parts of a ship for ventilating purposes are all motor-driven, and the air being regulated in temperature before entering the compartment, serves the double purpose of being used for both heat and ventilation. This system also comes under the chief engineer's care. There are over 80 auxiliary engines on board some boats, besides an extensive plant in connection with the water-tight doors, controlled from the bridge. All water-tight doors can be closed in an instant in case of accident.—"Marine Review."

Record of Pasadena's Municipal Plant*

SYNOPSIS—With a graduated rate of 5 to 3c. for lighting and 4 to 1.2c. for power the plant earned 8.18 per cent. with an annual output sold of 3,154,883 kw.-hr. Basing the saving over the old rates before municipal ownership, the plant has paid for itself in five years.

In 1907, Pasadena, Calif., installed a municipal plant which has been remarkably successful and has furnished current for power and lighting at exceptionally low rates. Annual reports have been issued from the time of its inception, and some of these have been given space in POWER. The sixth annual report for the year ending June 30, 1913, is now available, and gives some very interesting data on operating records and costs.

It will perhaps be well to enumerate the equipment of the plant before giving a summary of the operating records. The plant has been equipped with 1100 hp. in boilers of the B. & W. and Stirling types, and a new 400-hp. boiler is now being installed. There are 2000 hp. in cross-compound condensing engines, and 2000 hp. of Parsons steam turbine, making a total generating capacity of 4000 hp. The number of service connections totals 6556, and the idle service connections 1779. The total connected three-phase motor load is 2036 hp., and besides there are 326 hp. in single-phase motors, so that the total power load is 2362 hp. The street-lighting system consists of 278 inclosed arc lamps, 3259 tungsten lamps of various ratings, and 222 ornamental lights. The area of the city is 11.2 square miles, and there are 150 miles of streets.

According to the financial data given in the report, the undepreciated value of the plant is $608,028.04. The net value of the plant depreciated is $504,564.98, and adding to this the cash on hand, accounts receivable, and the inventory of construction material and supplies on hand, makes the total asset value of the plant $541,400.35.

From the output report, it will be noted that the total current generated amounted to 4,022,230 kw.-hr. The manufacturing cost of all current generated amounted to $0.00916, the distribution cost $0.00826, the interest $0.00516, and the depreciation $0.00610, making a total of $0.02868 per kw.-hr. On the basis of current sold, the total cost per kilowatt-hour increases to $0.03656.

OUTPUT REPORT

Output in Kw.-hr. for Year Ending June 30, 1913

Street Lighting	Kw.-hr.	Receipts	Receipts per Kw.-hr.
Clusters and alleys	216,090	$7,249.93	$0.03355
Arcs and series tungstens	654,750	38,462 00	0.05874
	870,840	$45,711.93	0.05249
Commercial System			
Lighting (including city bldg.)	1,557,999	$74,138.80	0.04759
Power	726,044	19,038.68	0.02622
	2,284,043	$93,177 48	0.04079
Total sold	3,154,883	138,889 41	0.04402
Lighting at plant	24,229		
Lighting at stockroom and office	11,777		
Testing lamps	715		
	36,721		
Light loss, or unaccounted for current	830,626		
Total current generated	4,022,230		
Received for all current generated			$0.03453
Received for all current sold			0.04402

	Mfg.	Dist.	Int.	Dep.	Total
Cost of all current generated	$0.00916	$0 00826	$0 00516	$0 00610	$0 02868
Cost of all current sold	0.01168	0 01054	0.00657	0.00777	0.03656
Kw.-hr. per bbl. of oil					131.85
Efficiency of distributing system, per cent.					78.44
Load factor, as per peak load, per cent.					28.69
Load factor, total for amount of machinery, per cent.					15.05
Revenue per kw. station capacity					$45.54

The operation account includes earnings and expenditures. The accompanying summary will no doubt be of interest.

OPERATION ACCOUNT

	1912–13	1911–12
Earnings		
Street lighting	$45,711 93	$40,714.45
Commercial light and power	93,177 48	82,770.66
	$138,889 41	$123,485.11
Expenditures		
Manufacturing:		
Fuel oil	$22,998 41	$22,371 37
Lubricants	1,176.63	1,339.74
Wages at station	7,306.86	7,040 93
Water at station	33.35	148.95
Miscellaneous manufacturing supplies	882 39	1,727.90
Repairs to building	182 07	356.16
Repairs to steam equipment	3,807 31	2,852.13
Repairs to electric equipment	453 80	440.54
Total manufacturing cost for year	$36,840 82	$36,277.72
Total distribution cost for year	$17,148 30	$13,746 83
Total general cost for year	$16,084.33	$13,675.75
Total	$70,073.45	$63,700.30

At the time of the inauguration of the plant, a base rate of 12½c. per kw.-hr. was charged for the first 666 kw.-hr. While this rate was lowered to meet the 8c. rate established by the city for current supplied to its municipal plants, the 12½c. base rate continued in force in various other southern California cities supplied by the company in competition with the city of Pasadena. Ultimately, the base rate in some of the various other cities was reduced to 10c., until Jan. 1, 1913, when a base rate of 8c. was established. In all probability, however, if it had not been for the example set by the people's plant in Pasadena, the other southern California cities would not now be enjoying an 8c. base rate. The facts are that the difference between the 8c. rate charged in these other cities and the 5c. rate charged by Pasadena's municipal lighting plant shows that there is a difference of 37½ per cent. in favor of municipal ownership, as against regulation. Or, to put it in another way, the consumers in other cities, outside of Los Angeles, pay 60 per cent. more than the consumers of the Pasadena municipal plant.

Pasadena claims a saving of not less than $408,000 from Oct. 1, 1908, to June 30, 1912, as a result of the establishment of its light and power works. To this should be added the saving resulting for the year ending June 30, 1913, which, if compared on the same basis of the old rate, would be not less than $223,625.96, and if figured at a maximum rate of 10c. for six months, and a maximum base rate of 8c. for six months, according to the rates paid by some of the other southern California cities, the saving would be not less than $149,083.96, making a grand total, when figured in the first way, of $631,625.96, and when figured in the second way, of $557,083.96.

There has been a great saving in the cost of street lighting as compared to the rates formerly paid by the city to the competitor of the municipal plant. Street arc lamps now cost 23 per cent. less; incandescent street lighting, 40 per cent. less, and ornamental cluster light-

*From sixth annual report of Pasadena's Municipal Lighting Works Department, by C. W. Koiner, electrical engineer and general manager.

ing at least 20 per cent. less than formerly paid. At the time the city began lighting its streets it had only the benefit of 50,000 cp. for street lighting, for which it paid $15,808.40. At the present time the city has 267,500 cp., or 4⅓ times more light, for which the city paid the past year $45,711.93. Another great advantage that must not be overlooked in making this comparison is that the service rendered for street illumination is far superior to anything the city had before it began illuminating its streets from its municipal plant. From the above, it is plainly evident that Pasadena, by reason of the difference in electric rates, has saved sufficient during the last five years to pay for the entire plant.

Details of the rates for lighting and power will no doubt be of interest, and are therefore included in the following:

SCHEDULE OF LIGHTING AND POWER RATES

Street Lighting

Arc lamps, 6.6 amp., $60 per annum.
40 cp. tungsten, 6.6 amp., $12 per annum.
80 cp. tungstens, 6.6 amp., $24 per annum.
250 cp. tungsten, 6.6 amp., $48 per annum.
350 cp. tungsten, 6.6 amp., $60 per annum.
Cluster posts, 3c. per kw.-hr., plus lamp renewals.

Incandescent Lighting

Class A—The first 100 kw-hr., or less, of energy furnished in any one month to any consumer, 5c. per kw.-hr.

Class B—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 100 kw.-hr. and not exceeding 500 kw.-hr., 4½c. per kw.-hr.

Class C—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 500 kw.-hr. and not exceeding 1000 kw.-hr., 4c. per kw.-hr.

Class D—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 1000 kw.-hr. and not exceeding 2000 kw.-hr., 3½c. per kw.-hr.

Class E—The kilowatt-hours of energy furnished in any one month to any consumer over 2000 kw.-hr., 3c. per kw.-hr.

Arc Lighting

Class A Arc—The first 100 kw.-hr., or less, of energy furnished in any one month to any consumer, 4.9c. per kw.-hr.

Class B Arc—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 100 kw.-hr. and not exceeding 500 kw.-hr., 4½c. per kw.-hr.

Class C Arc—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 500 kw.-hr., 4c. per kw.-hr.

A minimum monthly charge of 60c. per meter of 3 kw. capacity or less, and 30c. for each additional kilowatt of meter capacity required, shall be made for each meter.

All energy furnished through or measured by a meter used for any incandescent lighting shall be paid for at incandescent lighting rates.

All energy furnished through or measured by a meter used for measuring energy used in arc lighting and not for any incandescent lighting, shall be deemed arc-light energy.

Upon request of consumer separate meters will be furnished for incandescent lighting, arc lighting and power and heat purposes.

Carbon and Gem lamps of such candlepower as the department can conveniently carry shall be furnished free for renewal purposes to all consumers.

Power

From and after Feb. 1, 1913, and until changed by the Council of the city of Pasadena, the rates for electric energy furnished by it for power, heating or purposes other than lighting, shall be as follows:

Class A Power—The first 100 kw.-hr. of energy or less, furnished in any one month to any consumer, 4c. per kw.-hr.

Class B Power—The kilowatt-hours furnished in any one month to any consumer in excess of 100 kw.-hr. and not exceeding 300 kw.-hr., 2.4c. per kw.-hr.

Class C Power—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 300 kw.-hr. and not exceeding 500 kw.-hr., 2.4c. per kw.-hr.

Class D Power—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 500 kw.-hr. and not exceeding 1000 kw.-hr., 2c. per kw.-hr.

Class E Power—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 1000 kw.-hr. and not exceeding 1500 kw.-hr., 2c. per kw.-hr.

Class F Power—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 1500 kw.-hr. and not exceeding 2000 kw.-hr., 1.9c. per kw.-hr.

Class G Power—The kilowatt-hours of energy furnished in any one month to any consumer in excess of 2000 kw.-hr. and not exceeding 3000 kw.-hr., 1.8c. per kw.-hr.

Class H Power—The kilowatt-hours of energy furnished in any one month to any consumer over 3000 kw.-hr., 1.2c. per kw.-hr.

A monthly minimum charge will be collected for electrical energy of $1 per meter of 1½ kw. capacity or less and $0.75 for each additional kilowatt of meter capacity required.

To Retire the "Imperator" from Service?

According to a German dispatch, "the Hamburg-American Line, in spite of earlier denials say that the boilers of the 'Imperator' have proved unsatisfactory, and that complete rebuilding is necessary in order to reduce the excessive coal consumption and to increase the speed of the vessel."

It is said that the builders by their contract were required to compensate the company for the compulsory retirement of the "Imperator" from service, and will have to pay about $1500 for every day she is laid off.

Technology Club Honors Prof. Sweet

The Technology Club, Syracuse, N. Y., on the occasion of its 11th annual meeting honored Prof. John E. Sweet, one of its founders and first president, by establishing the John E. Sweet lecture fund.

The fund, intended as a permanent testimonial to the venerable engineer, educator and inventor, is to be used for the maintenance of a lecture course in which distinguished speakers on both technical and popular subjects will be brought to Syracuse each year. The first lecture for 1913-14 will be given about Nov. 1.

The club has elected the following officers: President, James P. Barnes; second vice-president, Glenn D. Holmes; secretary, A. R. Acheson (reëlected); treasurer, M. B. Palmer (reëlected); directors for two years, Arthur J. Briggs and Harvey N. Smith.

Staten Island Boiler Explosion

Six people were killed and four injured by the explosion of a boiler in the Livingston station of the Richmond Light & Railway Co., Staten Island, N. Y., about 4:30 p.m., Tuesday, Oct. 21. The boiler which exploded was a Wickes boiler in a battery of three installed in 1901. It was projected upward through the roof almost vertically and came down bottom first in the Kill Von Kull. Except for damage to the brick work the other two boilers in the same battery were uninjured. The pressure carried was 180 lb. The bottom head of the lower drum was found among the débris in the basement and showed the failure to have occurred in almost a perfect circle where the curvature changed to form the flange. The coroner and the Public Service Commission intend to make a thorough investigation into the accident and we expect to be able to present further details in a subsequent issue.

As a consequence of the explosion most of Staten Island was without electric light that night and only a few cars were without electric light that night and only a few cars were running such as could be operated with the current supplied by the company's smaller station at Concord.

PERSONALS

De Witt Smith, formerly of Meriden, Conn., has been appointed chief engineer of the plant of the Trenton & Mercer County Traction Corporation, Trenton, N. J.

Hudson Dickerman, of the Johns-Pratt Co., Hartford, Conn., who had the misfortune to lose both hands in a roller at the mill, is recovering, and hopes to be on the road in the near future. Mr. Dickerman's host of friends will be delighted to know that he will regain his health and once more be about.

OBITUARY

RUDOLF DIESEL

Dr. Rudolf Diesel, the German engineer, famous through the invention of the type of engine which bears his name, disappeared from a steamer en route to Harwich, England, from Antwerp, on the night of Sept. 29. His body was found in the River Scheldt, more than a week later. His untimely death, and the mysterious circumstances surrounding it, just at a time when his invention was assured of success, caused a stir throughout the whole mechanical world.

Dr. Diesel was born of German parents, in Paris, in March, 1858, and commenced his elementary education in Paris schools. When the war of 1870 broke out, his parents went to England, and shortly after their arrival they sent their young son to Augsburg. After courses of study in the Augsburg technical schools, young Diesel entered the Munich

DR. RUDOLF DIESEL

Technical College, where he was graduated in 1879, and became assistant to Prof. von Linde. He then spent a short time in practical work at Messrs. Sulzer Brothers' works, Winterthur, on leaving which he was appointed manager of the French company for the manufacture in Paris of the von Linde refrigerating machinery.

The deceased engineer had from his student days been engrossed with the idea of discovering a prime mover having a much higher thermal efficiency than the steam engine, and in 1893 he described in his book, "Theorie und Konstruktion eines rationellen Wärmemotors," the engine he had designed. Dr. Diesel's theories attracted great attention in Germany and throughout the whole world, with the result that he was afforded financial aid by Messrs. Krupp and the Augsburg-Nuremberg Co. for the construction of an engine of the type he advocated. The first Diesel engine, a vertical stationary one, was built in 1893. This was on the four-stroke-cycle principle, the piston driving the shaft by a piston-rod and an external crosshead. The cylinder was not water-jacketed. A feature of this first engine was the low camshaft, resulting in the provision of long rods for operating the valves. The starting storage-chamber consisted of a wrought-iron pipe having riveted flanges; there was no air-supply pump, and the fuel was injected directly. This engine could never be made to run. It was driven by outside power, and at the first injection of fuel, as Dr. Diesel remarked, an explosion occurred, the indicator broke up, and pieces from it nearly killed the inventor. The occurrence showed, however, that pure air could be compressed to such a degree that it could ignite the oil fuel.

The second engine, built immediately afterward, had a water-cooled cylinder, and its camshaft was fitted higher up; its main difference, as compared with the first, was in the provision of an air-supply pump for injecting the oil fuel. This second engine did not run to any extent, and its working was attended with much danger. With it, however, Dr. Diesel was able to obtain a few indicator diagrams of the whole cycle. This engine confirmed the practical possibility, shown by the first, of initiating combustion by compressed air, which the inventor had shown to be theoretically possible.

The first reliable Diesel engine, the third attempt, was built on Diesel's designs by the Augsburg Co., in 1897, after the inventor had carried out a series of experiments over a period of four years with the second engine. The third engine was of the vertical one-cylinder stationary type on the four-stroke-cycle principle, developing 18 hp.

In the years that followed several types were experimentally developed and Dr. Diesel continued to incorporate improvements with each successive engine. It might be said that the Diesel principle was soon found to be most applicable to a two-stroke-cycle engine, scavenging being carried out with pure air, and not with a fuel-air mixture, there being thus no risk of premature ignition and no fuel losses.

When last year Dr. Diesel put before the profession the history of his engine, he stated that the two-stroke-cycle was then, in 1912, on almost an equal footing with the four-stroke-cycle type, adding that this latter had a better combustion, more economical fuel consumption, and was simpler in its method of working. The four-stroke-cycle, therefore, remained the standard engine for medium-size stationary plants. The two-stroke-cycle engine, on the other hand, had smaller cylinders, and had come into favor for stationary plants of higher power; this latter engine seemed also to be, according to Dr. Diesel, the standard type for ship propulsion.

The first Diesel engine for ship propulsion was built in France, in 1903, by Messrs. Adrien Bochet and Frederic Dyckhoff, in conjunction with Dr. Diesel. The first marine Diesel engines were not reversible; they drove electric generators, and this made it possible to reverse the direction of rotation of the propeller. The first direct-reversing marine Diesel engine, working on the two-stroke-cycle principle, was built by Sulzer Brothers, Winterthur, in 1905.

Many builders have been for the past two or three years contemplating the construction of Diesel engines of high power for the propulsion of battleships and cruisers.

The latest application of the Diesel engine is for railway traction purposes, developed and built at the Sulzer Bros. plant. Dr. Diesel's patents for Great Britain were in the hands of the Consolidated Diesel Engine Manufacturers, Ltd., with new works at Ipswich, while the American rights formed the basis for the organization of the Busch-Sulzer Bros.-Diesel Engine Co., with new works in St. Louis, Mo.

CHARLES TELLIER

Charles Tellier, the inventor of the cold-storage process, who was reported a few days ago to be dying in want, died on Oct. 19, at the age of 85. His misery was relieved by subscriptions raised for him by the Cold Storage Co. a short time before his death.

Mr. Tellier discovered the present method of refrigerating meat some 30 years ago and celebrated the occasion by taking a number of friends on a vessel on which all the viands served had been preserved by his system. He built a number of works, but like most geniuses he never could save any money. He had one son, a delicate youth of 22, who seemed to be his whole care.

SOCIETY NOTES

The offices of the New England Association of Commercial Engineers have been moved to the Equitable Building, 67 Milk St., Boston, Mass.

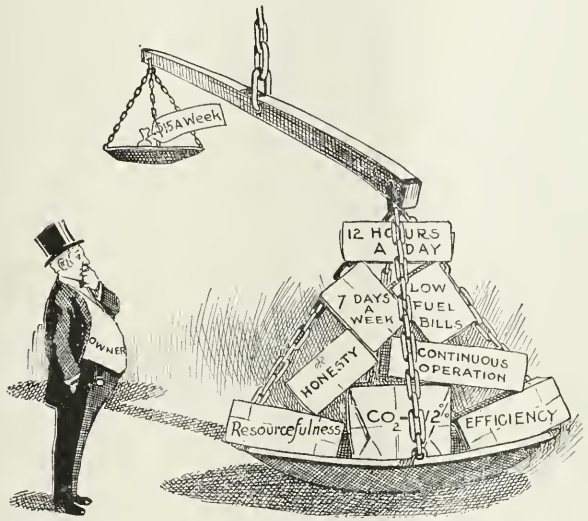
At the regular meeting of the Louisiana Engineering Society, held on Monday, Oct. 13, in Gibson Hall, Tulane University, New Orleans, an illustrated paper, "Recent Developments in Evaporation," was read by A. L. Webre, engineer of the J. H. Murphy Iron Works.

The Detroit Engineering Society, on the evening of Oct. 3, gave a smoker and new members' night, at which 46 new members were admitted. About 200 members and friends listened to an informal talk by R. D. Follett, secretary of the Detroit Zoological Society on "The Aesthetic Side of the Conservation Problem." It was illustrated by a most interesting series of colored motion pictures.

POWER

ol. 38 NEW YORK, NOVEMBER 4, 1913 No. 19

A Question of Balance



MR. POWER PLANT OWNER—REFLECT A MOMENT! *Is the scale in your plant evenly balanced? That is, in proportion to what your engineer puts on his side of the scale, are you correspondingly loading the other pan?*

□ □ □ □

If not, your engineer cannot be satisfied, at least not for long. If he is not satisfied, then ten chances to one, he is on the lookout for another job and his successor may cause the beam to tip the other way by not having so many nor so heavy packages to put into the pan on his end.

A man who is paid according to the number, size and quality of the packages he delivers will stick to his job.

First get the right man and for every additional weight put on his end of the beam, add sufficient remuneration to balance the scale evenly. You will find it excellent economy.

[*Written by Everard Brown, Pittsburgh, Penn.*]

The 25,000-Kw. Turbine for Fisk Street

SYNOPSIS—Detailed information regarding this unit has been eagerly looked for ever since the announcement of the placing of the order. Its great capacity, low steam rates, and the fact that is of foreign make combine to make it an object of engineering curiosity and interest.

The 25,000-kw. turbine which we announced some time ago had been ordered from C. A. Parsons Co., Ltd., by the Commonwealth Edison Co., of Chicago, is being erected in the Fisk St. station of that company and should be ready for operation early in the winter. This unit marks not only the limit in capacity for which a single generator has yet been built but also the lowest guarantee which has yet been offered for steam rates, unless the guarantee has been beaten by that of the 30,000-kw. unit now being built by the General Electric Co. for the Northwest station of the Commonwealth company.

The figures for the Parsons turbine are:

At 10,000-kw.	12.50 lb. per kw.
15,000-kw.	11.65 lb. per kw.
20,000-kw.	11.25 lb. per kw.
25,000-kw.	11.65 lb. per kw.

These figures include the energy necessary for excitation purposes, but do not include the energy necessary for ventilating the generator, nor for the condenser or other auxiliaries.

The steam conditions upon which this guarantee is based are 200-lb. gage pressure, 200 deg. F. superheat at the throttle, and an absolute back pressure equivalent to 1 in. of mercury.

The Rankine efficiency, or ratio of work produced to that which would be produced by a 100 per cent. engine working upon the Rankine cycle between the given limits of pressure and temperature, is 72.4. It is said that a penalty of £500 ($2500) is incurred for each one-fifth of a pound in excess of 11.25 at 20,000 kw., and that an equal bonus will be paid for any improvement in that rate.

A longitudinal section of the unit is given on the plate herewith, and reproduction of photographs taken at the Heaton works of the Parsons company, at Newcastle-upon-Tyne, England, where it was built, are reproduced on pages 631 and 633. The turbine is in two sections, a single-flow, high-pressure section with six stages or groups of blades, and a double-flow, low-pressure section, also with six groups of blading upon each side of the entry.

The High-Pressure Turbine

Steam enters the high-pressure belt *A* from below, through the opening *B*. The secondary, or overload steam belt, is shown at *C*, high-pressure steam being automatically admitted thereto through the opening *D* when the load rises sensibly above 20,000 kw. The entry blading is 2¾ in. in height and must pass 225,000 lb. of steam per hour, 62.5 lb. per second, at the guaranteed steam rate and normal load. The final blading for the high-pressure section is 6½ in. in height. The diameter of the entry-blade circle is about 52 in., and of the final blade circle about 72 in., giving mean blade speeds of about 170 and 235 ft. per sec. respectively at the rated speed of the turbine, 750 r.p.m. Those of the blades which are subjected to the action of superheated steam are of copper; the remainder of brass. All are heavier at the base than at the tip, and are lashed by silver-soldered binding strips. Three dummy pistons *E, F, G* are used to balance the end thrust, equalizing pipes *H* and *I*, connecting the chambers *hh'* and *ii'*, while the pipe *J* transmits the outlet pressure in the chamber *j* to the space *j'* back of the largest dummy.

The casing is four-parted with one horizontal division in the plane of the axis and a vertical division between the fourth and fifth rows of blading. The high-pressure end is of cast steel, the remainder of cast iron.

The two smaller dummies *E* and *F* and the high-pressure end of the main shaft *K* are integral with the drum and of forged steel, specified to have an ultimate tensile strength of 35 to 40 tons per square inch, and an elongation of 20 per cent. At the exhaust end the drum is shrunk on and bolted to the enlarged end of a separate length of shaft *L* of the same material.

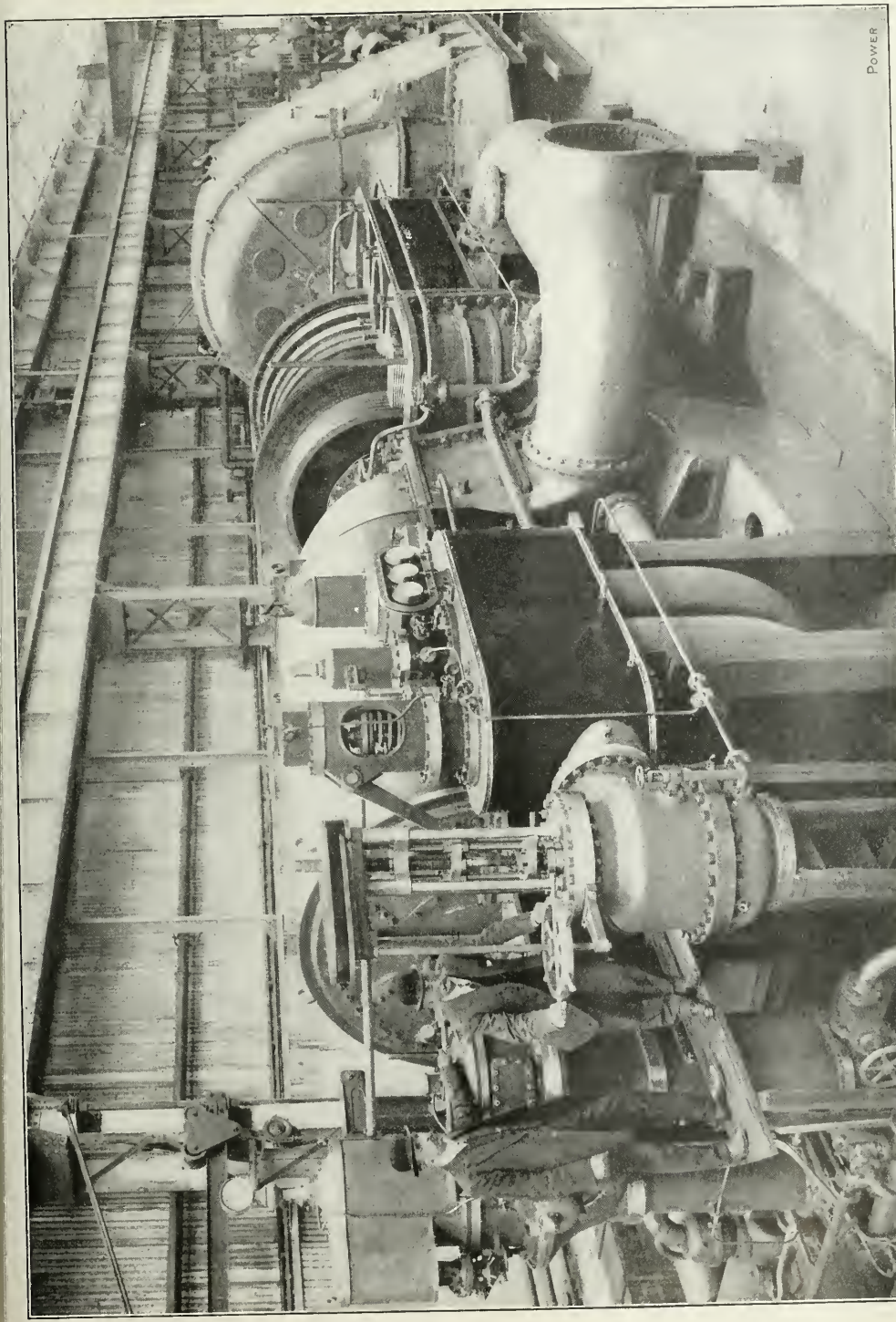
There are in the six groups of high-pressure blading 64 rows of moving blades, and steam in passing through them is expanded to a pressure of about 25 lb. absolute under normal conditions, which would make this section develop quite some less than one-half the total load.

The Low-Pressure Turbine

From the exhaust belt *M* of the high-pressure section steam passes by two 30-in. pipes to the central steam belt *N* of the low-pressure section, where it divides, passing through the blading in both directions to the exhaust chambers *PP*. The blading ranges from 2¾ in. at the entry to 19 in. at the discharge. The mean diameters of the blade circles are about 87 and 103 in., giving average blade velocities of 285 and 337 ft. per sec. The low-pressure section has 24 rows of moving blades on each side of the center. The drum is of uniform diameter and is attached to the shaft through connections which allow their relative position to vary under differences of temperature without affecting the register of the blading. The central spider *Q* stiffens and supports the drum at the point where the radial clearance on account of the shortness of the blades must be kept at a minimum, and stability and maintained precision are of particular importance. The casing of the low-pressure section is of cast iron throughout and weighs about 150 tons. The bottom portion is built in four, the top in two sections, as the drawing indicates. The standard Parsons low-pressure gland is used on both ends, sealed with steam exhausted from the governor relay. The final blades discharge the steam practically into the condenser itself.

The Condenser

The condenser shell, which is suspended from the bottom of the turbine so that it forms practically a continuation of the turbine case, is built of steel plate externally stiffened by bulb irons or deck beams so as to present no unnecessary obstruction to the movement of the steam within. The tube-supporting plates and water ends are of cast iron; the tube plates and tubes of brass. The tubes are 1 in. in diameter, 16 B.w.g. and 15 ft.



THE LARGEST TURBINE AND GENERATOR YET BUILT. VIEW FROM HIGH-PRESSURE END

ng, arranged in two groups for two water passes. The ıtrance orifice is 69x26 in., and the discharge pipe 18 ı. in diameter. The rectangular opening where the ndenser shell joins the turbine case is 12x21 ft., giving section of 252 sq.ft. Allowing that 20 per cent. of the eam is condensed by the conversion of its heat into ork, this passage will have to pass at normal load 2,136,- 00 cu.ft. per min., which means an average velocity of early 8500 ft. The greater part of the weight of the ndenser and its contents is carried upon springs, of hich there are eight, placed upon beams set into the ncrete foundation, as shown at *RR*. The condenser ntains 39,300 sq.ft. of tube surface, being 1.965 sq.ft. r kw. at the normal, and 1.57 sq.ft. at the maximum ting. In addition to the main condenser, a feed-water

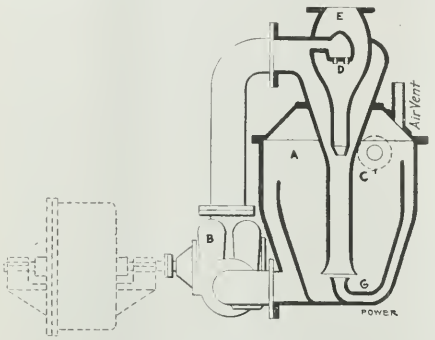


Fig. 1. Kinematic Ejector

ater section is to be built in the steam entrance into ıe condenser and to contain 470 sq.ft. of surface.

The equipment of pumps to be used for condenser ıxiliaries and for other purposes in connection with is unit, is being furnished by Henry R. Worthington, d consists of:

One horizontal tri-rotor, volute, motor-driven centrifu- l pump for circulating water, having a capacity of 42,- 00 (U. S.) gal. per min.

One horizontal, two-stage, motor-driven, centrifugal otwell pump, having a capacity of 750 gal. per min.

One horizontal, centrifugal, motor-driven pump, for se with the kinetic injector, having a capacity of 4000 l. per min.

Two horizontal, centrifugal, motor-driven, surface mps, having a capacity of 300 gal. per min. each.

One turbine-driven and one motor-driven type cen- ifugal boiler-feed pump, having a capacity of 750 gal. r min. each.

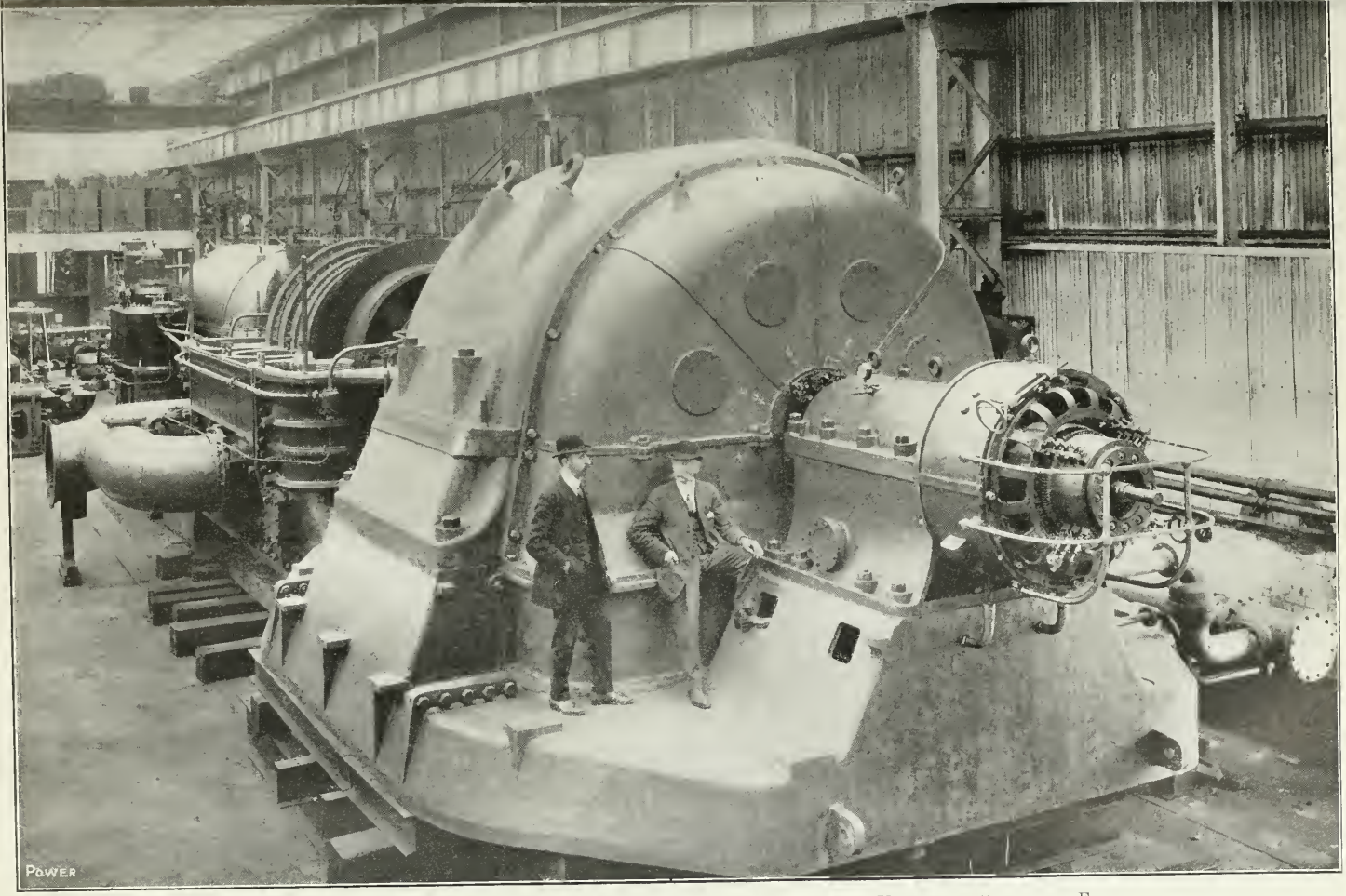
The motor-driven auxiliaries are equipped with squir- l-cage induction motors.

In place of the usual air pump, a kinetic ejector, fur- shed by Richardsons Westgarth & Co., of West Hartle- ol, England, is used. This ejector is shown diagram- atically in Fig. 1. The discharge from the hotwell pump ows through the chamber *A*, discharging therefrom rough the flanged outlet *C*. An ordinary centrifugal mp *B* draws a portion of this condensate from the nk *A* and returns it to the spray nozzles *D*. The air om the condenser is pushed into the chamber *E* by a eam jet, as will be seen upon the large plate, where the ector is shown in a somewhat different form from this diagrammatic presentation. The air and condensable vapors are carried along by the water jets which issue under pressure of some 40 lb.; the vapor is largely condensed and the air caught in the air pipe *G* is carried above the water level and discharged through the vent, avoiding the aërating of the feed water, while the heat from the steam jets and the condensed vapor is returned to the boiler with the condensate.

In the ejector, as actually applied to the turbine, and shown in the large plate, the kinetic tank consists of three sections; the middle section constitutes the kinetic tank proper, which has just been described, in addition to which there is a tank on one side which performs the function of the feed-water heater, and on the other side is a hotwell from which the feed pumps take their suction. The latter is provided with a float connected to the makeup water supply, which maintains an adequate supply for the feed pumps. The kinetic tank proper has an outside chamber into which the water overflows from the central chamber, in which the nozzles are arranged in annular form, passing through a number of copper strainers, the water flows from this section to the feed-water heater, where it is heated by a number of steam jets which are supplied with steam from the connection between the high- and low-pressure cylinders on the turbine, or from the steam-driven boiler-feed pump. The feeder section is connected with the hotwell by a passage running through the bottom part of the kinetic tank.

Should the supply of water in the hotwell tank be more, temporarily, than the demand of the boiler-feed pumps, the excess will pass out through the overflow pipe, which runs into a large reservoir, located below the level of the basement floor. The use of this reservoir serves to save the pure water of condensation, which would otherwise be wasted. When the supply in the hotwell becomes deficient, a float valve serves to establish a connection from the reservoir into the condenser, thus furnishing the necessary makeup water. An additional float valve in the large reservoir serves to maintain the level at a predetermined height and admits water from the filtered-water system in the station. The two turbine sections are connected through a rigidly bolted coupling *S*. Between the low-pressure turbine and the generator is a flexible claw coupling *T*, which is fitted with a worm pinion through which the turbines may be turned by an electric motor when they are open for inspection. The longitudinal expansion is provided for by allowing the foot of the turbine at the high-pressure end to rest freely on the pedestal between slipper side guides. Each turbine and the generator stands between its own pair of bearings, making six bearings in all. The overall length is 76 ft. 2 in. The greatest width is 19 ft. The height from the base of the condenser to the highest part of the turbine is 30 ft., of which only 10 ft. is above the floor level.

The steam-admission valves, the steam-governor valves, the emergency and bypass valves, and the chests containing them, are steel castings which have been used wherever the part came in contact with superheated steam, and, like the cast-steel portion of the turbine casing, were annealed before and after rough machining. This portion of the turbine is of the standard Parsons design, with separate emergency and regulating governors, the latter being controllable from the switchboard. It is specified that the regulating governor shall not allow the



25,000-Kw. Parsons Turbine for the Fisk Street Station, Chicago. View from Generator End

load to vary more than 3 per cent. between no load and 25,000 kw., with a momentary variation of not more than 5 per cent. In addition to the two governors mentioned, a safety governor is attached to the end of the high-pressure turbine shaft independent of the main governors, and capable of being tripped by hand from the engine-floor level. A steam resetting gear is provided for this valve.

We are indebted for permission to acquaint our readers with the details of this remarkable machine to Samuel Insull, president of the Commonwealth company, and for access to the drawings and information to Sargent & Lundy, of Chicago, consulting engineers to the company.

Improved Pen for Chart-Recording Instruments

The chart records from recording water or steam meters and pressure gages, which are usually placed on permanent file, form an increasingly important part of the daily history of the plant's performance. Often, however, the line drawn is very broad and sometimes blotched or spotted, making the diagram unsightly and difficult to read, or to integrate accurately, especially if the curve is somewhat irregular; sometimes, soon after the pen has been filled, the chart acts as a blotter soaking up the entire filling in one huge blot. These faults may be traced

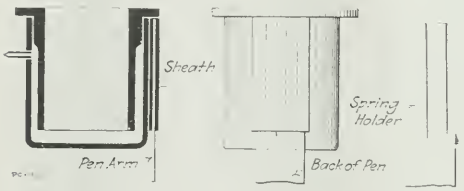


Fig. 1 Fig. 2 Fig. 3

Details of Pen

to the use of poor quality ink, or of improper consistency, but more frequently to defects in the pen which traces the line.

The pen shown in cross-section in Fig. 1 was designed to avoid pen troubles. The general shape is that of a cylinder, about $\frac{3}{8}$ in. in diameter and of the same height. This pen depends for its action on two principles: Capillary attraction and the inverted siphon. It is made in two parts, both of bronze; the outer shell and the inner partition to which the cap or cover of the pen is joined. The inner dividing wall descends to within $\frac{3}{64}$ in. of the bottom of the ink reservoir. Two concentric chambers are thereby formed, the inner being open and the outer covered by the cap. The edge of the latter is knurled so that it may be easily grasped with the fingers when it is desired to take out the inner shell for the purpose of starting or cleaning the pen.

A short piece of bronze tubing, not over $\frac{3}{32}$ in. in length, nicely smoothed and rounded at the end, forms the pen point proper. The short length is found to be of advantage; long tubes clog easily and after their interior is caked with ink, cleaning is next to impossible.

The method of fastening the pen to its holder is illustrated by Figs. 2 and 3. The end of the pen arm terminates in a spring fork which is inserted in a sheath at the back of the pen. This method of fastening holds the pen rigidly and, since no solder is used to make the joint, the pen may be easily removed from the arm when ever desired.

When starting, the cover of the pen is removed and the reservoir filled with ink to about three-quarters of its depth (it is not necessary to have the inlet of the tube submerged when starting). The cap is then replaced and brought home by a slight pressure on the top, keeping the opening covered by the thumb. The slight air pressure thus brought into action on the surface of the ink in the reservoir is sufficient to force a small amount through the tube which forms the pen point.

Fig. 4 shows a chart made by the first pen used on a Venturi meter type M register-indicator-recorder, measuring boiler feed water. Seven charts can be made from a single filling of the pen.

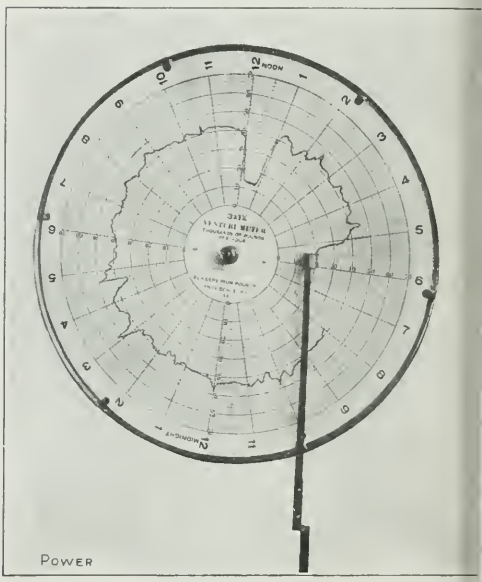
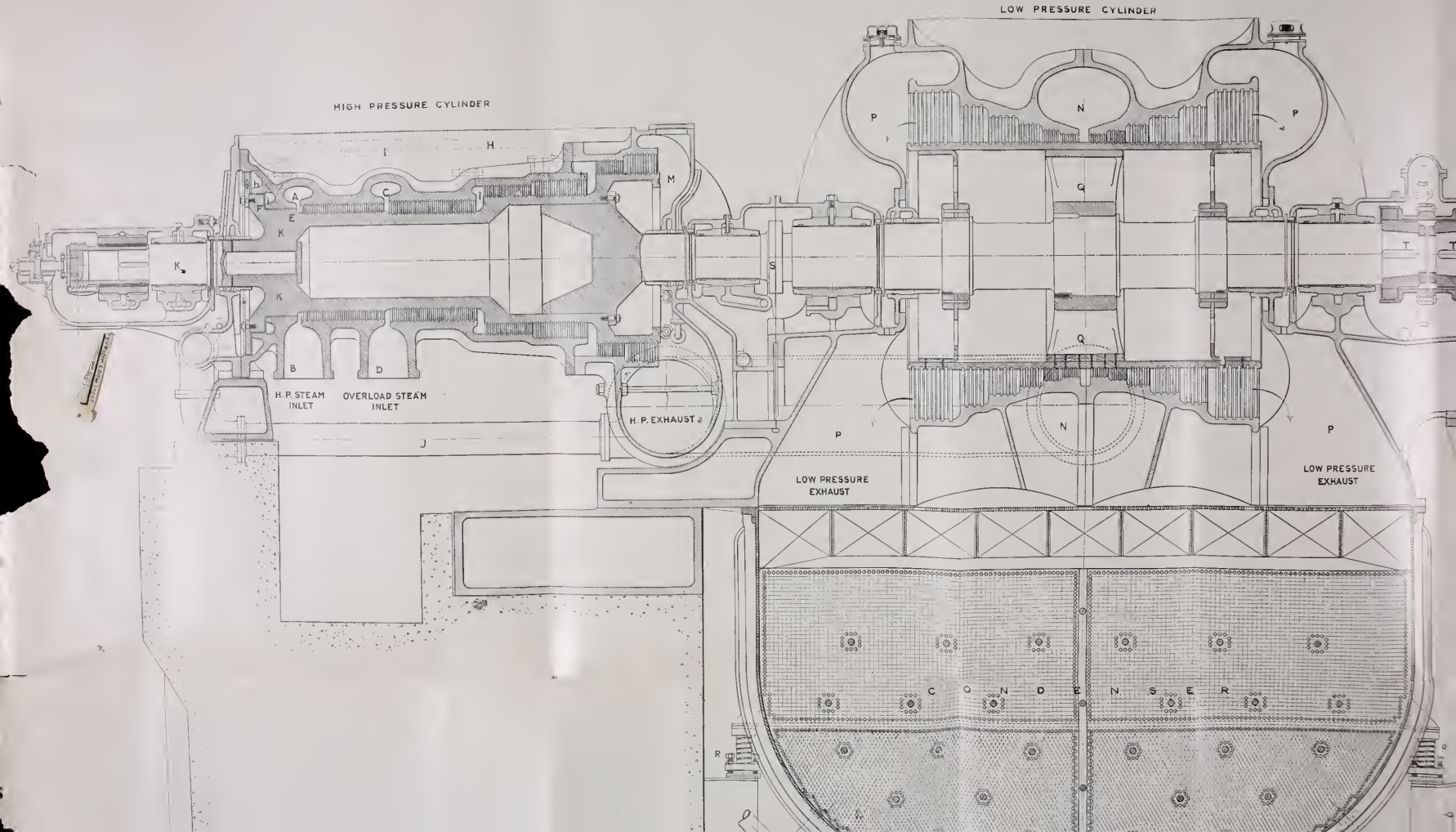


Fig. 4. Chart Made with New Pen

The level of ink in the pen is always visible without removing the cap. It has been found by test that the tubular point of the pen will draw the ink from the outer reservoir until the level drops below the middle when the siphon "breaks." If the pen is refilled before the "breaking point" is reached, the feeding is continuous without pause and it is unnecessary to remove the cap to start the pen. The short tube is easily cleaned by picking it with a fine wire.

The pen, which is made by the Builders Iron Foundry, Providence, R. I., will soon be furnished with all of the Venturi meter-recording instruments. The pens may be procured, however, for use with almost any type of recording instrument and are easily applied. Both pen and pen arm are finished in heavy nickel-plating.


HIGH PRESSURE CYLINDER
LOW PRESSURE CYLINDER
H. P. STEAM INLET
OVERLOAD STEAM INLET
H. P. EXHAUST
LOW PRESSURE EXHAUST
LOW PRESSURE EXHAUST
C O N D E N S E R

LOW PRESSURE CYLINDER

GENERATOR

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EXHAUST

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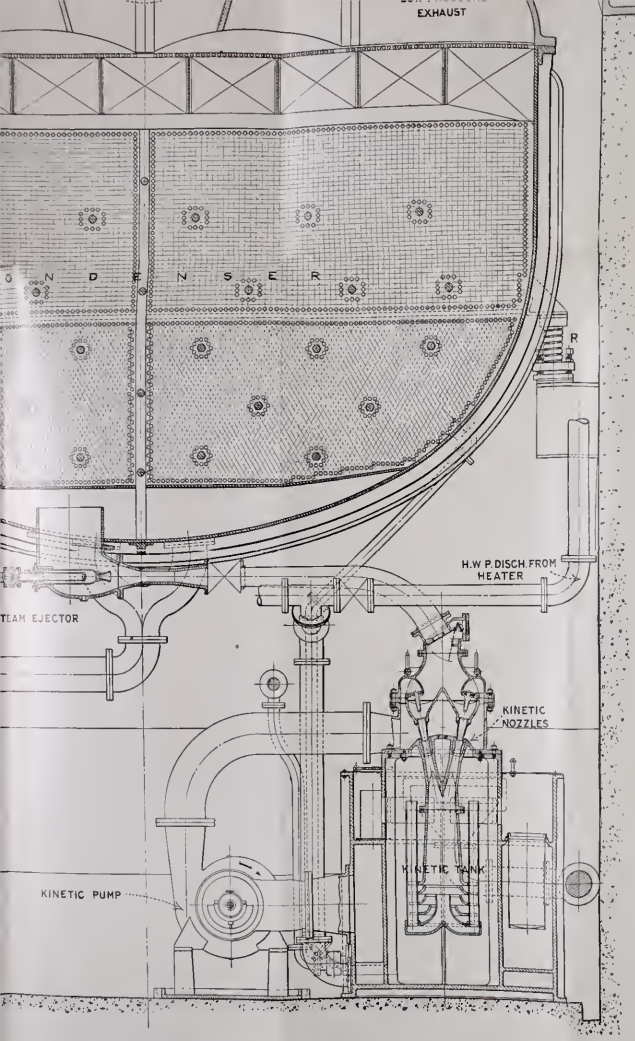

LONGITUDINAL SECTION OF 25,000-KW. PARSONS TURBINE-DRIVEN UNIT FOR FISK STREET STATION OF THE COMMONWEALTH EDISON COMPANY OF CHICAGO

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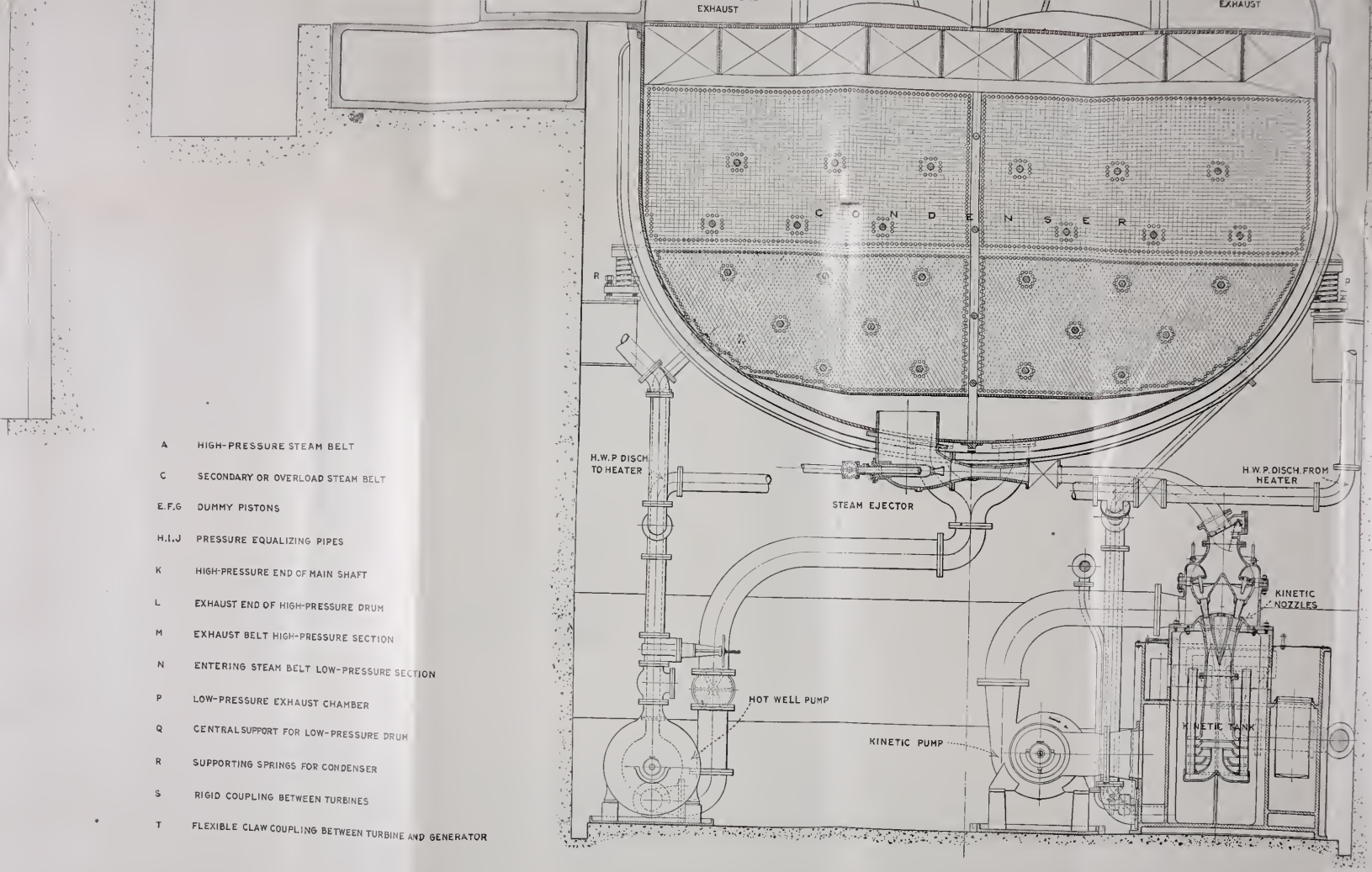
SCALE IN FEET

SUPPLEMENT TO POWER NOVEMBER 4TH, 1913. VOLUME 38, NO. 19



A HIGH-PRESSURE STEAM BELT

C SECONDARY OR OVERLOAD STEAM BELT

E.F.G DUMMY PISTONS

H.I.J PRESSURE EQUALIZING PIPES

K HIGH-PRESSURE END OF MAIN SHAFT

L EXHAUST END OF HIGH-PRESSURE DRUM

M EXHAUST BELT HIGH-PRESSURE SECTION

N ENTERING STEAM BELT LOW-PRESSURE SECTION

P LOW-PRESSURE EXHAUST CHAMBER

Q CENTRAL SUPPORT FOR LOW-PRESSURE DRUM

R SUPPORTING SPRINGS FOR CONDENSER

S RIGID COUPLING BETWEEN TURBINES

T FLEXIBLE CLAW COUPLING BETWEEN TURBINE AND GENERATOR

Boiler Attachments—IV

By J. E. Terman

YNOPSIS—Fusible plugs are shown to be a disadvan-ge unless properly placed and cared for. Something said regarding hand stop valves, also automatic back-ressure valves, their position in the pipe line and how combination of both is advisable.

A fusible plug, like any other automatic device, requires little intelligent attention at stated intervals, in order hat it may be of service when required. The filling of a sible plug should be removed at least once every year nd pure tin should only be used for refilling. A fusible ug should be examined once a month, and both the rfaces exposed to the gases and to the water should scraped clean. On many types of boilers a fusible ug is of doubtful utility, and on some its use is detri-ental. For example, on the vertical tubular type of oiler the fusible plug is necessarily placed in one of e tubes, and it is very difficult to make the joint be-een the tube and plug tight. The plug after being rewed in place usually projects into the tube such a stance that it is impossible to pass a brush or scraper rough it, consequently, the tube gradually fills up with ot and scale until it is completely stopped. If no s from the furnace passes through the tube, of course, e fusible plug is useless and the only result is the ss of the use of the tube for generating steam.

The usual location for a fusible plug in a horizontal, turn-tubular boiler is in the rear head about two to o and a half inches above the tops of the top tubes, d this is about the only place that it can be success-lly applied. One of the troubles connected with the e of fusible plugs, is, that when a plug burns out it quires the closing down of the boiler to renew it; after e or two experiences of this kind, it seems hard for e average boiler attendant to resist the temptation to place it with a solid plug. On the locomotive-type iler, the fusible plug should be placed in the crown eet and project about an inch above the top of the eet. The fusible plug is probably more efficient as a v-water alarm on the locomotive-type boiler than on y other. For water-tube boilers, the fusible plug ould be placed at the lowest safe water line and at e nearest point to the furnace in the direct path of e gases from the fuel bed. The fusible plug may be nsidered an antiquated type of low-water alarm and functions are much better and more economically rformed by more modern appliances, which can be ted to ascertain if they are in working order or not, thout actually having low water in the boiler.

Stop Valves

The stop valve is an important part of the boiler equip-nt and not only must it be of good construction, but must be properly located, if it is to give satisfactory rvice. In general, a stop valve should be located as ar the boiler as possible, so that the steam may be cut should any defect occur in the piping. Another fea-re that sometimes makes it desirable to locate the stop lve near the boiler, is that, when long connecting pes are used between the boilers and a steam header serving a number of boilers, if the stop valves are not located near the boilers, severe strains may be produced in the piping due to the contraction of the pipes con-nected to idle boilers, should the stop valves be located near the header.

Another requirement, the most important of all, in re-gard to the location of the stop valve, is that it should be so placed that no water of condensation can stand in the pipe when the valve is closed. Failure to observe this necessary precaution for safety has often resulted in the loss of life or the serious injury of those in charge, due to the breaking of fittings or pipes from water-hammer action; such accidents have also at times led to the explosion of the boiler itself. Fig. 21 illustrates a bad arrangement in this respect, that is frequently met with in practice. The dotted lines show two positions for the header that would remedy the defect. If the conditions are such that the stop valve can not possibly

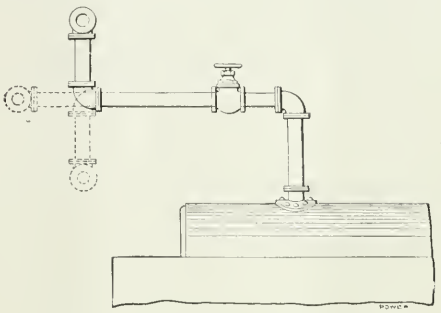


Fig. 21. Improper Steam-Pipe Connection

be located so that the condensed steam will drain back into the pipe line, then a bleeder of ample size should be provided and located so that it will drain the pocket. The boiler attendant should regard it as his most important duty to see that the piping is thoroughly drained before attempting to cut a boiler in on the line.

There is another feature that should influence the location of the main stop valve, if the first two mentioned do not absolutely fix its position, and that is accessibility for operation. The normal purpose of this valve is to cut the boiler from the line to shut it down or re-connecting it after a shutdown. Under such conditions the operator can usually go to the top of the boiler to perform this duty at leisure. However, when an accident occurs and it is required to cut a defective boiler out, to prevent the other boilers from emptying their steam through the defective one, the matter is different. Under such conditions, if a hand-operated valve is used, it is generally impossible to reach it if placed in the usual location. The best method of over-coming this difficulty is to put a chain-sprocket wheel on the valve stem in place of the regular handwheel and lead a chain from this wheel over suitable pulleys to a point where it can be readily reached from the boiler-room floor level.

The automatic stop valve is, of course, the best kind of equipment for the purpose we are discussing, for it stands ready at all times, if in working order, to shut off a boiler when the pressure on the boiler side drops below the line pressure. While the automatic stop valve performs this important function, it also performs another of equal if not greater importance, and that is, it automatically prevents connecting a boiler to the steam line until the pressures on the two sides are equalized, if the valve has been made operative before an excess pressure has been built up in the boiler.

To really protect a boiler operated with others, and the attendants who may be required to work inside when shut down, the stop-valve equipment should consist of two valves, one an automatic placed nearest the boiler and the other an ordinary stop valve. This arrangement allows the pressure to be removed from the automatic valve at any time without shutting down the entire battery of boilers, and if a bleeder valve of ample size is located on the main pipe between the two valves, steam and hot water may be kept from entering the boiler, even if both valves are not perfectly tight. The reduced effort to clean a boiler and the better cleaning done when interference by steam and hot water is eliminated will often pay for an extra valve in a short time, to say nothing of the better facilities offered for inspections.

The question of which way the stop valve should be turned in connecting it, if of the globe-valve type, is often raised, and it can be discussed, pro and con, in many ways. If the plant consists of more than one boiler, the importance of being able to pack the stem without taking the pressure from the steam line would seem to require that the top side of the valve be connected toward the boiler. If dependence is to be placed on a single globe-stop valve, there is possibly less liability of the breaking of the parts and admitting steam to an idle boiler by reversing the position; so, with a single valve used, it is safest to turn it so that the line pressure will be on top of the disk when closed, and safety is of paramount importance.

Another precaution for safety that should be taken to protect those who may be required to work inside idle boilers, and this applies especially to large plants, is to provide chains and locks, for locking shut the stop valves as well as other valves that control connections that may admit hot water or steam to an idle boiler. The keys to such locks should be kept by the chief engineer or other attendant in responsible charge. It would seem that the recital of some of the details of the frightful accidents that have occurred with considerable frequency on the account of neglecting such precautions, would be sufficient to secure from the management any reasonable sum for the necessary equipment.

Dampers and Damper Regulators

The damper is a more important portion of the boiler equipment than is usually credited. When horses are hitched together, the draft gear is usually arranged so that it will be necessary that all pull alike, but the average steam engineer will hitch from two to ten or more boilers together without apparently giving the matter much thought as to whether each will carry its proper share of the load or not. The main function of the individual boiler damper is to aid the operator to distribute the total load between the boilers according to the capacity of each one. The correct distribution of the load on plant efficiency is of importance.

It is well known that the economy, as regards fuel consumption, is much less with a boiler carrying a small load than if it were operated at rating or slightly above, and that a loss of efficiency is also experienced if an excessive load is carried. Therefore, when two or more boilers are operated on a load that approximates their combined capacities, the efficiency will be maximum when the load is distributed between them in proportion to their capacities, and the efficiency will be less the greater the inequality in the distribution of the load. Under bad conditions of distribution the loss in fuel may amount to 10 or even 20 per cent. of the fuel consumed.

The individual damper in the uptake from each boiler can be used to distribute the load properly by producing the required draft conditions in the furnace under each boiler so that the proper amount of heat may be generated to suit the capacities of the different boilers. The best way to judge when the loads are properly equalized is to have a steam-flow meter attached to each boiler so that the actual amount of steam delivered to the line may be seen, but if the management of the plant can not be induced to purchase such equipment the engineer should not be discouraged, for paying attention to the amount of coal burned under each boiler, will soon give a clue to the proper adjustment of the dampers for equalizing the load on the various boilers. If one boiler has twice as much heating surface as another has, it should care for twice the amount of heat, and the furnace should be capable of consuming twice the amount of fuel and delivering to the boiler twice the amount of heat. Sometimes it will be found that the grate area will require changing so that the load may be properly distributed.

After the positions in which the individual dampers must be placed to properly distribute the load have been determined, they should be marked and kept at these positions whenever the boiler is in operation, unless changed conditions in the plant make a readjustment necessary. All regulation of the draft that is required to care for changing load conditions, should be cared for by a main damper, placed in a portion of the main flue that carries the gases from all the boilers to the chimney. By this means the proper distribution of the load between the different boilers is maintained under changing load conditions. The damper regulator should always be arranged to operate the main damper.

Plants are frequently found where a regulator is attached to each individual boiler. This arrangement can never give the best results, regardless of the value of the regulator used, because it is impossible to adjust the different regulators to work in unison. There are many different makes of damper regulators on the market, but all work on about the same principle. A rising steam pressure actuates a valve which admits steam, air or water to a cylinder, and the movement of the piston in the cylinder closes the damper. The reversal of the operation is accomplished by weights or other means, when the boiler pressure has dropped below a given point.

A point about dampers that properly should be cared for by the boiler maker, but which the engineer should understand, is that they must not be made to fit tight

in the flue. A tight damper is liable to stick due to warping or expansion, and it is also liable to give trouble by causing gas explosions in the flue. There should always be sufficient draft on a boiler to prevent the formation of, or to remove, the gases that may be distilled from the bed of fuel when the draft is cut off; for unless this gas is carried off as fast as it is formed, serious explosions are liable to occur.

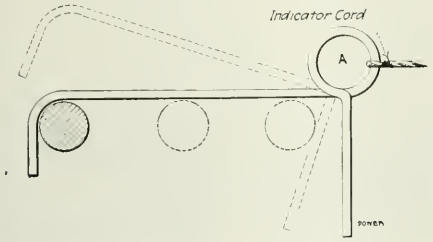
When firing a boiler, it is necessary to open the firing door wide, and this permits a rush of cold air to enter the furnace if the damper is open. To prevent this, the dampers are sometimes arranged so that they are automatically closed on each boiler as the furnace doors are opened. This is a good scheme, and it doubtless relieves the boiler of considerable strain due to sudden changes in furnace temperature. Since a damper regulator operates on differences of steam pressure only, without reference to furnace conditions, it should be set to operate at a pressure somewhat higher than the ordinary running pressure desired, in order that the fireman may regulate the pressure by his method of firing as far as possible. It is wasteful of fuel to have large quantities of green coal lying on the fuel bed with the draft checked, for under these conditions large quantities of the combustible portions of the coal escape up the stack unburned.

Handy Hook for Indicator Cord

By Paul A. Baumeister

The illustration shows a hook that is of material assistance in hooking up an indicator cord, while running at high speed. This device has lately come to the writer's attention and it may be new to others.

As shown, it consists of a special hook made from stiff wire. The hook is driven from a bar connected to the



Indicator-Cord Attaching Hook

crosshead. To hook up while running the loop A is held between the thumb and first finger of the right hand, the hook being held in the position shown by the dotted lines. The left hand is held loosely around the string to catch the hook should it fail to catch. The hook is now moved toward the bar on the crosshead until the bar strikes the end of the hook. This will swing the hook between the thumb and finger to a horizontal position, as indicated by the full lines. On the forward stroke the bar will catch the hook, pulling the latter out of the hand. The dotted lines under the hook show how the hook may rest on the pin and hook on.

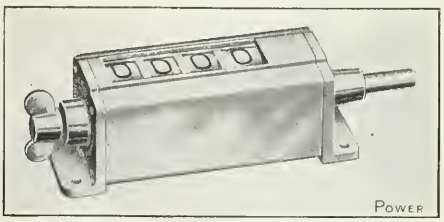
To disconnect the hook the hand is held loosely around the indicator cord and moved toward the hook until the arm of the hook strikes the fingers. This will tip up the hook and unlatch it.

Veeder Setback and Locked-Wheel Counters

The illustration shows one of the counters which have been brought out by the Veeder Manufacturing Co., Hartford, Conn.

The four-wheel setback counter is shown herewith. When desired the counter can be turned forward by one turn of the knob, shown at the left end of the counter, until all of the figures are at zero. The resetting shaft picks up the number of wheels from any position and carries them forward to zero.

The counter is built up of units, each unit consisting of a short section of shell, which carries a pinion and incloses the number wheel, with the exception of an opening through which the figures are read. The usual number of wheels supplied is four, but the counter may be



Veeder Setback Counter

made up with but two, or in special cases, with six or even eight sections. The counters are dust-proof and may be made waterproof by a suitable cement placed around the glass.

In the center of each number wheel is a small single-toothed ratchet wheel or cam, which engages with a single pawl, attached to the number wheel. The small cams are provided with a key which engages with a groove or keyway in ths resetting shaft.

The locked-wheel counter is similar to the setback counter, except that the transfer pinions are solid and the number wheels are not provided with cams and pawls for setting them to zero. The number wheels are locked in all positions and cannot be moved, except through the mechanism which is provided for driving the right-hand ring.

Both styles of counters are furnished with the same form of driving mechanism. A rotary ratchet drives the right-hand wheel forward by an oscillating motion of the lever on the driving shaft. The driving shaft may be rotated through any number of degrees, or even revolved continuously in either direction. If driven forward, it will count 10 for each revolution; if driven backward, the number wheel will not be moved. An oscillating movement of from 40 to 60 deg. will count one figure at each movement.

In the direct drive, the driving shaft is directly connected to the first or right-hand wheel and one revolution of the driving shaft will count 10. If the shaft is run backward, the number will be subtracted.

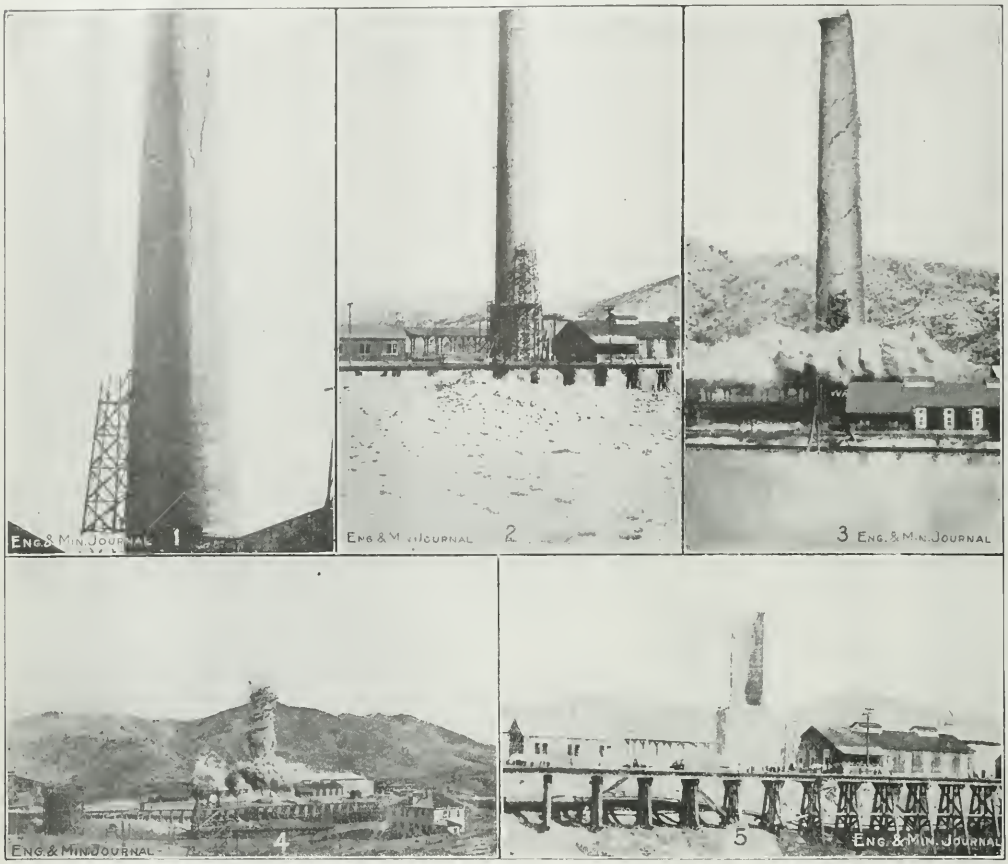
In the revolution counter, the right-hand wheel is driven by a gear, mounted on an eccentric on the driving shaft, but is prevented from turning by a short oscillating link. It counts one figure for every revolution of the shaft.

Wrecking the Balaklala Stack at Coram, Calif.

The tall, hollow-tile stack at the works of the Balaklala Consolidated Copper Co., at Coram, Calif., was recently wrecked by blasting out the lower part of the round portion of the stack, just above the octagonal base. The stack was 275 ft. high; the octagonal base about 10 ft. high. After the stack had been used 18 months, it began to crack and flatten on one side. Some people said it had been struck by lightning, but it is not positively known that this is true. The condition of the stack on the south side is shown in Fig. 1. Where the cracks are, the stack had bulged out, and on the left, where the iron ladder-rungs can be distinguished, the stack had flattened so that when one went inside and looked up, there was probably 10 or 12 ft. of the inside which, instead of being a circle, was practically straight across.

Many plans for saving the stack were discussed, such as banding, etc.; but as every few days a lot of brick would fall from the cornice, making it extremely dangerous, it was feared that, by working on the stack, some of the men might be injured. Fig. 2 is the photograph taken from the west side of the stack and shows how the top had crumbled away, several feet of it having fallen from time to time. In Fig. 3, the condition of the stack at the time of firing the blast, and just before it fell, is shown. In Fig. 4 the stack is shown a little later than in No. 3. Fig. 5 shows a piece remaining after the blast. This piece was taken down a few days later.

In wrecking the stack, 72 holes were drilled around half of the base, and in each hole three sticks of 40 per cent. powder were placed, and all the holes were fired simultaneously by an electric battery. It is understood that the hollow tile of which this stack was built were imported from Germany. The cost of the original stack was $35,000. It is probable that the stack will be rebuilt to a height of 40 or 50 ft. above the 10-ft. base, using the same old material; possibly it may be built higher.—*The Engineering & Mining Journal.*



FAILURE AND WRECKING OF THE HOLLOW-TILE STACK OF THE BALAKLALA CONSOLIDATED COPPER CO.

In June a 135-ft. brick stack in Cleveland, Ohio, was struck by lightning, causing almost the same condition shown in Fig. 1.

ELECTRICAL DEPARTMENT

Sixty-Cycle Rotary Converters*

By B. G. Lamme

One of the most significant developments in the past year has been the greatly increased use of large 60-cycle rotary converters by central stations. Shortly after the 25-cycle converter became prominent in electrical work, that is, 15 to 18 years ago, the problem of 60-cycle converters was also presented and such machines were built and installed in a number of places. Some of these were fairly successful, while others were failures. Apparently, in some of these cases of failure, the converter itself was not entirely to blame, as it was operated under conditions which would now be considered impracticable.

Peripher Speeds

Relatively low speeds were considered necessary from the commercial standpoint, and with 60 cycles this meant a large number of poles. Also manufacturing limitations called for relatively low peripheral speeds of the commutators. In those days commutator speeds much in excess of 4000 ft. per min. were considered prohibitive, and unduly dangerous. The peripheral speed of the commutator equals the distance between adjacent neutral points multiplied by the alternations per minute. On this basis, 3600 ft. peripheral speed with 60 cycles per second gave 6 in. between adjacent neutral points. Even 4200 ft. peripheral speed gave only 7 in. between neutral points. It is obvious therefore that, even with this higher peripheral speed of the commutator, there was undue crowding of the brush-holders; itself a bad feature. But the worst feature was that, with only 7 in. between the commutator neutral points, the permissible number of commutator bars was unduly limited. In consequence, 60-cycle converters for 250 to 300 volts rendered better service than 600-volt machines.

The field flux distribution had something to do with the questionable operating conditions. With these earlier machines, very high peripheral speeds of the armature core were considered objectionable for several reasons. One was, that the constructions did not allow very high peripheral speeds of the armature windings, and a second was that, with the relatively low speeds and large number of poles, the armature dimensions and cost would have been excessive. In general, a 12-in. pole pitch was considered as large as desirable or practicable, which corresponds to 7200 ft. per min. at 60 cycles.

With this small pole pitch, in order to obtain a sufficiently wide commutating zone between the poles, it was necessary to make the poles relatively narrow. The use of narrow poles led into one difficulty, as regards flashing, while widening the pole and narrowing the interpolar space led to another difficulty of flashing which was equally serious. An obvious remedy was in the use of wider pole pitches, but increasing the pole pitch, with a given number of poles and given speed, meant increasing the diameter of the armature, and, even though the armature could thereby be narrowed, the cost of the larger-diameter machine would necessarily be increased. The remedy for this condition was a reduction in the number of poles as the pitch was increased, thus keeping down the size of the armature for a given output. But reduction in the number of poles means higher speeds, which were formerly considered commercially objectionable. Therefore, between commercial limitations, difficulties in design and manufacturing conditions, the 60-cycle converter was in a bad way.

Attempts were made from time to time to increase the speed by decreasing the number of poles, but this could only be done commercially in relatively small steps. However, with increased experience in commutator constructions, one great advance was made by increasing the commutator speeds of the 60-cycle machines. Instead of approximately 7 in. between points, the distance was increased to 8½ or 9 in. for 600 volts, giving 5100 to 5400 ft. peripheral speeds at the commutator. This allowed as many as 45 to 48 commutator bars per pole, which is well within the range of good 600-volt practice. This reduced the average and the maximum volts per bar, and one of the principal weaknesses of the former designs was eliminated. Also, by improved mechanical design which allowed higher peripheral speed of the armature windings, the pole pitch could be increased to about 16 in., instead of 12 in., without an unduly large diameter of armature. This also allowed a much better field flux distribution, and better interpolar space.

With increased speed and decreased number of poles, the current per brush arm on the larger 60-cycle machines has gradually increased until it is practically double that of former practice. This higher current per arm, with the increased number of commutator bars per pole, and the higher speeds, all tend toward making the commutation more difficult. But at this stage in the development, the commutating pole began to loom up as a possibility in rotary converters, and this has furnished the latest important step, making still higher revolutions permissible.

With these higher speeds, and greater outputs with a given diameter of machine, the losses have not increased anything like in proportion, so that the efficiencies of the 60-cycle converters have been increasing until now they closely approach the 25-cycle machines. In fact, when the greater efficiency of the 60-cycle step-down transformers is considered, the difference in units of large capacity is small.

Commutation

There were a number of other minor conditions in these earlier machines which might be considered as mechanical defects, or mechanical and electrical combined. These were found principally in the brush-holder and commutator construction, and in the materials of the

*From a paper read before the Association of Edison Illuminating Companies.

commutator. On the higher-voltage machines, in which a large number of commutator bars per pole was necessary, the thickness of each bar was, and still is, very small, and the proportion of thickness of mica between bars to the thickness of the bars is considerable. On this account, it has been difficult to obtain a wear or abrasion of the mica equal to the so called copper wear. No matter how perfect the commutation may appear there is always a slight tendency to burn the face of the commutator by the current passing between the commutator and the brushes. This may be extremely slow, but if the mica does not wear down at the same rate it will lift the brush surface away from the copper, and thus an almost infinitesmal gap exists between the brush, and the commutator. This gap then exaggerates the burning tendency, and the difficulty is accentuated. This trouble is also accentuated by high commutator peripheral speeds. Hence, in 60-cycle rotary converters, in general, and in high voltages in particular, experience has shown that it is advisable to undercut the mica slightly, to avoid any tendency toward high mica, and also to be able to use brushes which contain some lubricant, such as graphite. Where any considerable grinding action by the brushes is necessary to keep down the mica, such lubrication is not practicable to the same extent.

Hunting

In the development of the 60-cycle rotary converter, there were other conditions beside commutation, flashing, etc., which had to be taken into account. The rotary converter is a synchronous machine, and must follow rigidly in step with the impressed electromotive force. The early machines in many cases, were operated from generators driven by slow-speed reciprocating engines, which did not run at uniform speed. As the engines and generators varied in speed periodically the frequency of the electric circuit varied to the same extent, and any synchronous apparatus operated on the system would also vary in speed. If the converter did not follow rigidly, it would hunt, the direct result of which was visible in bad operation at the commutator. In the normal rotary converter, when running properly in synchronism, there is practically no armature reaction such as is found in direct-current machines, for the alternating current supplied to the armature winding is in opposition to, and practically neutralizes, the magnetizing effect due to the direct current delivered. Therefore, as far as reactions on the field are concerned, it is quite different from a direct-current machine, and at full load, the armature has very little more effect on the field than at no load. However, when the converter is hunting, the current due to the hunting action is not balanced by the direct current delivered, so that this current acts like that in a straight alternating-current or direct-current machine, and sets up magnetic fluxes in the interpolar space, and under the edges of the poles, which are harmful. These fluxes create bad commutating conditions. Therefore, as a rotary converter hunts, there is usually periodic sparking at the brushes, which may become so bad that the machine flashes over. The corrective now universally applied consists in the use of copper dampers, or "cage windings," in the field pole faces.

The advent of the later 60-cycle turbo-generating plants has been a large factor in the successful development of 60-cycle converters. The problem of angular variation in speed of the prime mover has disappeared, and, therefore, the dampers on modern 60-cycle converters have to take care of only those secondary causes of hunting, which were present under the old conditions. Also, with the new high-speed machines having relatively wider poles, it is practicable to add many more damper bars per pole than in the older machines.

Commutating Poles

However, a new problem in hunting has come up in connection with the advent of the commutating pole, both in 25 and 60 cycles. In the commutating-pole generator, the ampere turns in each commutating-pole coil is sufficient to not only neutralize the entire magnetizing force of the armature winding per pole, but to also furnish an excess flux for commutating. In the commutating-pole converter, there is normally but little resultant magnetizing effect in the armature winding, due to the alternating and direct currents being normally in opposition, and, therefore, the commutating-pole winding must only be strong enough to neutralize the very small resultant armature reaction and give, in addition, a magnetic flux sufficient for commutation. In consequence, the ampere turns on the commutating-pole winding may be only 30 to 40 per cent. of the total armature-ampere turns, considered as in an alternating- or direct-current machine; whereas, in a direct-current generator, the commutating-pole winding is usually at least 125 per cent. of the armature-ampere turns. Therefore, the rotary converter cannot act as a generator or motor with good commutation, as its commutating-pole strength is then much less than required. As a generator or motor, the armature reaction may not only overpower the commutating-pole winding, but may set up a strong magnetic flux in the wrong direction, and render the commutating conditions worse than if the commutating pole were absent.

Herein lies a source of possible trouble with commutating-pole converters. In case there is hunting, the armature will act alternately as a generator and motor, and the magnetizing force of the armature may be such that it will demagnetize the commutating pole, or even reverse the flux under it, so that the machine acts in the same way as if it were operating with the current reversed in the commutating-pole winding, which would obviously give very bad commutating conditions. Therefore, when the commutating-pole converter hunts, it represents a worse condition than when a noncommutating-pole machine hunts to an equal extent. Hence somewhat better damping conditions are required than in the noncommutating-pole machine.

A new condition also developed in connection with self-starting of commutating-pole converters. In the older 60-cycle machines, starting motors were commonly used. Later practice tends toward self-starting, except in special cases. There are some advantages in this self-starting, and at the same time disadvantages, especially in the 60-cycle machines. The greatest advantage lies in the rapidity with which the converter can be started from rest and brought up to synchronism, together with the fact that no synchronizing devices are required. With the old starting motor, the machine had to be brought to synchronous speed and then thrown in step. This was more difficult with 60 cycles than with 25 cycles, and self-starting eliminates this trouble. On the other hand, while starting and accelerating, the rotary converter acts as an

induction motor and will take a relatively large starting current at very low power factor.

However, the new condition which developed with the advent of commutating poles, lies in sparking, and not in the starting current. As the rotary converter at the start acts like an induction motor, it has a rotating magnetic field flux set up, which travels around the armature. The armature coils short-circuited by the brushes form secondaries to, or are cut by, this field and, therefore, have relatively large electromotive forces set up in them, which develop large local currents. The electromotive forces set up in the short-circuited coils are usually somewhat greater in the 60-cycle converters than in 25-cycle machines, due to fewer conductors in series, and, therefore, the normal voltage per conductor is relatively higher than in the 25-cycle machines. Hence, at the start, the relative voltage per conductor generated by the rotating field set up by the armature winding will also be higher in the 60-cycle converter. Also, the number of commutator bars covered by the brush will usually be greater. Therefore, the short-circuiting action of the brushes and the sparking will be worse on the 60-cycle machines, but it is liable to be excessive on all large machines.

With the advent of the commutating-pole rotary converter, a still more difficult condition has been encountered in self-starting, namely, that the flux conditions in the zone of commutation of the short-circuited coils are materially higher than in the noncommutating-pole machine. In the latter type, while the short-circuited coils cut an alternating flux and therefore have local currents set up in them, these coils, in commutating or reversing these currents, lie midway between the poles, and therefore in the region where the conditions of reversal are easiest. But in placing the commutating pole directly over the short-circuited coils, the conditions of reversal of the short-circuited current are made much more difficult during starting. In consequence, during starting and accelerating, the sparking conditions in the commutating-pole type, both for 60 and 25 cycles, are much worse than in the older noncommutating-pole type. In fact, in the larger machines, the conditions are so bad that it has been found necessary to add brush-lifting devices which will lift all the brushes but two, during starting and bringing up to speed.

Voltage Variation

In the earlier 60-cycle machines the question of variable voltage came up in connection with 250- to 300-volt machines. The general means of voltage variation in these machines was almost entirely by means of induction regulators, or transformers. It is only in very recent years that the self-contained units, such as the synchronous-booster rotaries, and the regulating-pole type, have been brought forward. For 60 cycles, the synchronous booster appears to be the only really practical method, due largely to limitations in design and in space requirements. If commutating poles are to be used, then the regulating-pole type of machine, with main and auxiliary poles in addition to the commutating poles, requires a very crowded design of field, unless a larger pole pitch is chosen than in the synchronous-booster machine, in which there are only the commutating and the main poles.

Sixty-cycle rotary converters are now being manufactured in relatively large capacities, such as 1000, 1500 and 2000 kw. for 270 volts with synchronous boosters, and up to 2500 kw. for higher voltages. Larger capacities, for either voltage, can be constructed without difficulty, and with as good performance as in the capacities mentioned.

Diesel-Electric-Driven Ship

By J. R. Wilson

Perhaps one of the most interesting ships of the year is the "Tynemount," a vessel built to demonstrate the advantages of electric transmission in connection with the Diesel engine for the propulsion of large ships. Built for the Montreal Transportation Co., this vessel, which is of 2400 tons displacement, is equipped with two four-stroke-cycle, six-cylinder, 300-hp. Diesel engines driving three-phase alternators at 400 r.p.m.; the latter in turn supply a 500-hp. electric motor which drives a single propeller.

The engines are both divided into groups of three cylinders, and the camshaft of each is driven by a vertical shaft arranged between the two groups. The bedplate is cast in two pieces and bolted together, and joined with the alternator bedplate at the flywheel end of each engine.

Starting is effected by means of compressed air, three cylinders only being fitted with starting valves. A device for stopping the engine and means of controlling the amount of air delivered by the air compressor are also provided on the control pillar. Near at hand is the electric controller of the transmission system, the whole providing a compact and centralized arrangement for the operation of the propelling machinery; controls are also carried to the bridge. At the after end of each engine a three-stage air compressor is fitted, driven direct from an extension of the engine crankshaft. This extension also provides means for driving the lubricating and circulating-water pumps. The fuel pumps are driven by eccentrics from the camshaft.

The electrical equipment consists of two three-phase alternators, each coupled direct to one of the Diesel engines. These alternators, when running at their normal speed of 400 r.p.m., have an output of 270 amp. each per phase at 500 volts which absorbs the full power of the engine. One is provided with six and the other with eight poles, giving frequencies of 20 and 26.6 cycles respectively. An exciter is coupled direct to each alternator and is capable of giving an exciting current of 30 amp. for ample working, which can be increased up to 50 amp. while maneuvering.

These two generating sets supply a 500-hp. induction motor of special construction. The rotor is of the squirrel-cage type, but the stator is provided with two different and entirely separate windings, one of 30 and the other of 40 poles. When these two windings are supplied with current at 20 and 26.6 cycles respectively, they give the same synchronous speed of 80 r.p.m. The motor will then absorb the full power of both engines and drive the propeller at 78 r.p.m. This propeller speed corresponds to the fastest speed of the vessel.

In order to obtain a slower speed the connections are altered so that the 20-cycle alternator supplies the 40-pole winding of the motor; the 26.6-cycle alternator can be shut down and the 30-pole winding of the motor is

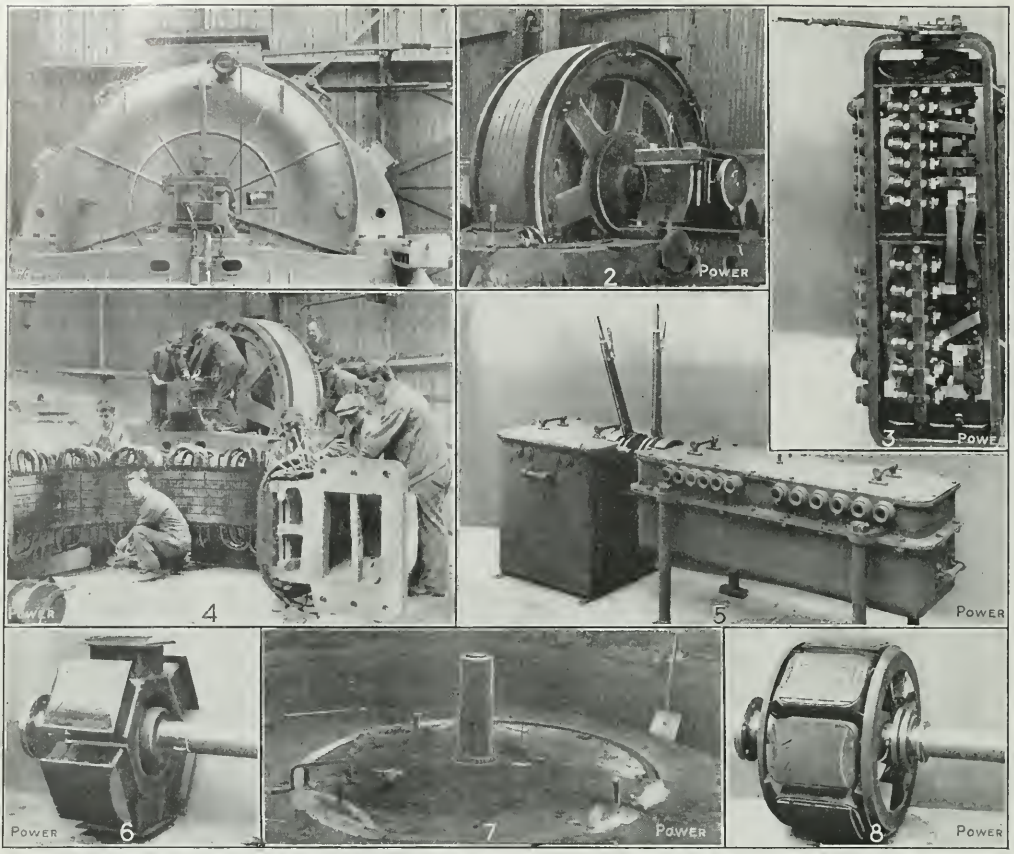


Fig. 1, motor complete; Fig. 2, rotor of motor in position; Fig. 3, main switch with cover and oil tank removed; Fig. 4, stator of motor in course of winding; Fig. 5, main switch and exciter switch with interlocking gear; Fig. 6, rotor of six-pole alternator before winding; Fig. 7, rotor of motor in foundry ready to cast on end rings; Fig. 8, rotor of eight-pole alternator

also out of service. The synchronous speed of the motor with the propeller is now reduced to 60 r.p.m. One of the engines only is available, but as the speed of the ship is reduced to about three-quarters normal, half of the total horsepower is ample and the great advantage is obtained of being able to entirely shut down that part of the plant which is not required at low speed. It will be noticed that the two alternators, when both are at work, are connected to entirely separate circuits and they are therefore never run in parallel. The process of paralleling would be quite unsuitable on shipboard as this operation not only requires skill and care but would involve considerable delay in starting the propeller motor.

Reversing is carried out by interchanging the connections of two phases. The switch gear provided for this purpose is extremely simple, consisting of two parts: a main switch of the tramway controller type having five different positions—full ahead, half ahead, stop, half astern and full astern, and of a second switch, the purpose of which is to introduce resistance into the shunt circuit of the exciter.

The contacts of both switches work under oil, but it is inadvisable that the contacts of the main switch should

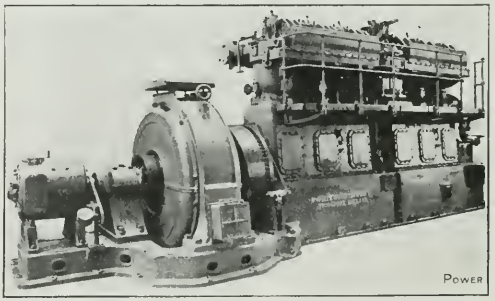


Fig. 9. Generating Unit Complete

be required to break the large main current flowing to the motor. The two switches are, therefore, interlocked so that it is impossible to work the main switch except when all the resistance has been introduced into the exciter field coils. There is then practically no excitation and the whole system is dead. With the resistance in the exciter field circuit, the main switch can be moved

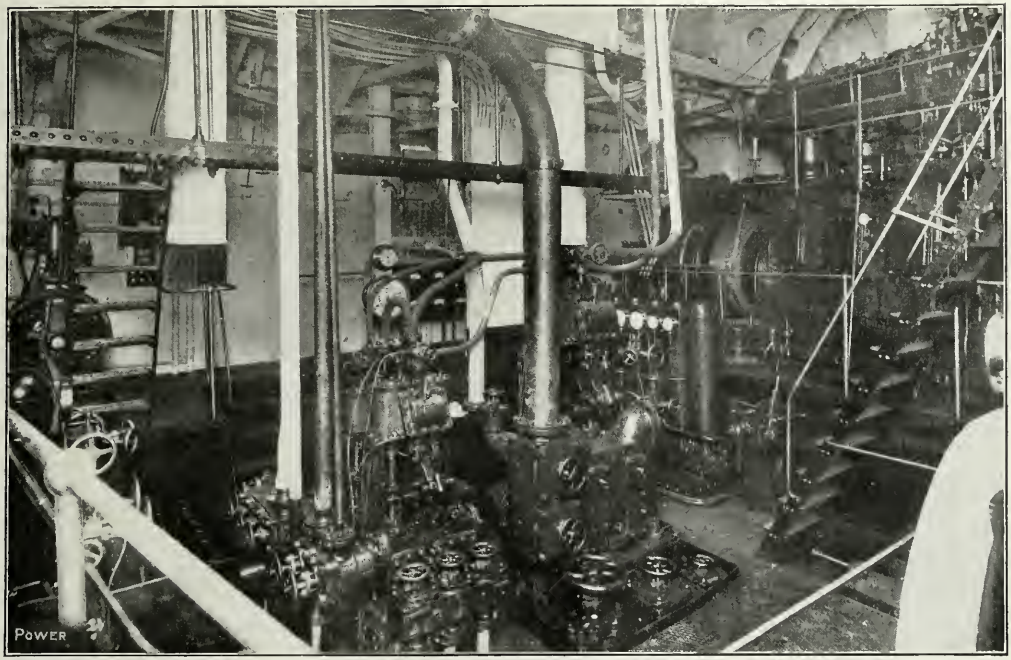


FIG. 10. GENERAL VIEW OF ENGINE ROOM, SHOWING ONE GENERATING UNIT AND CONTROL GEAR

to any one of its four working positions, and when the main connections have been made for the new running position the shunt-switch lever is pulled over so as to cut out the resistance and restore the excitation. Until the main switch is definitely on one set of contacts the shunt switch is locked so that the excitation cannot be restored. It will be seen that the whole handling of the ship can be carried out by means of two levers which are so interlocked as to be practically foolproof.

CORRESPONDENCE

Putting Tirrell Regulator in Service

Referring to Mr. Randolph's article in the Oct. 7 issue, on the Tirrell regulator, in my opinion his method of putting the instrument into service can be improved. To lower the line voltage to 65 per cent. below normal every time the instrument is put in operation, which is necessarily frequent in order to maintain the good condition of the contacts, would hardly make for good service. The following method has been found to raise the least disturbance and in fact it is impossible to detect when the regulator is being taken out or put back.

The single-pole switches at the top of the panel, connecting the control solenoids with the alternating current line and the exciter busbar are closed first in order to note the position of the main contacts. If they are closed, and consequently the relay contacts, to close the shunt-circuit switches which connect the latter with the taps on the exciter rheostat, would short-circuit the rheostat. This would cause more or less fluctuation in the line. If, however, the exciter voltage is raised slightly (but one or two volts being sufficient) the contacts will open. This rise is so slight as not to be apparent in the line.

The relay contacts being open, the shunt-circuiting switches may be closed without affecting the system. If the exciter voltage is now lowered about as much as it was raised, the regulator will swing into action slowly and smoothly. The rheostat can now be cut into the desired point, the only noticeable effect being a speeding up of the regulator.

On taking out the instrument, the reverse course is taken. By turning out the rheostat slowly, the speed of the contacts become slower until they stop, remaining open. The shunt-circuit switches can be opened and the regulator cut out of service for cleaning by opening the top switches.

L. W. CULTER.

Union Hill, N. J.

Erection of Stettin Electric Plant—The Kraftwerk Stettin, the company which furnishes electric current to the consumers in Stettin, Germany, and vicinity, is erecting a second plant, in order to supply the constantly increasing demand. When first erected the present plant had a capacity of 9,000,000 kw.-hr., which was increased to 12,000,000 by adding to the plant. The demand of large and small consumers will compel the production of 18,000,000 to 20,000,000 kw.-hr. in the near future. The new plant is to take care of this increase. Machinery of 12,000 to 15,000 hp. will be installed at once, but the plans are so arranged that it can be increased to 50,000 hp. When completed Kraftwerk Stettin will be one of the largest plants in Germany for the production of electric current. The buildings, to be located on the waterfront, will comprise boiler houses, engine rooms, and facilities for unloading and storing coal. Steam power will be used.

HEATING AND VENTILATION

Vacua Hot-Water Heating Applied to Woolworth Building*

By Ira N. Evans

From time to time articles have appeared presenting the feasibility of operating the power equipment of office buildings with condensing engines or turbines in connection with a cooling tower and a hot-water heating system under forced circulation, utilizing the exhaust steam under partial vacuum. It is the purpose of the present article to compare the operating economies of such an installation applied to the Woolworth Building with the present equipment of vacuum heating and noncondensing

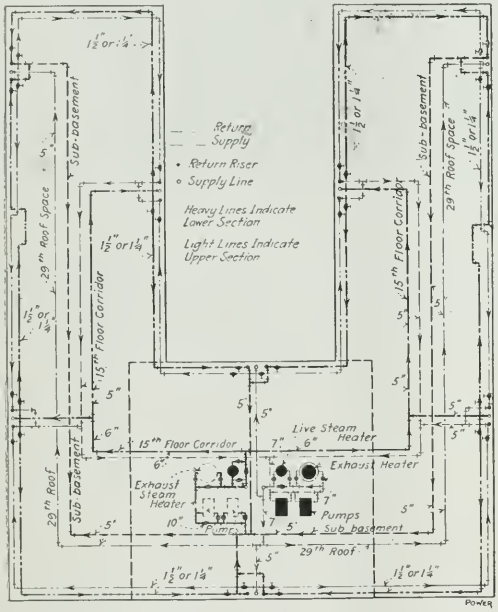


Fig. 1. Elevation of Proposed Layout

compound engines, as described in the June 24 issue of Power. It should be understood that criticism of present methods is not intended and that the proposed arrangement could only be applied to a building before construction. The subject can only be treated briefly, due to the allotted space, but discussion of this paper is invited in order to bring out any fallacy in the reasoning or design.

In view of the low dividends on investments in buildings of this class and the strides that have been made in the economy of condensing equipment and turbine construction, it is singular that these improvements have not been employed in this line of work. Turbines and condensers have not been successful under these conditions mainly on account of the fixed temperature and pressure required for the steam-heating system. The heating apparatus has a cooling capacity in winter equivalent generally to the average power load on the plant, which could be utilized at no expense if modified to suit the requirements of a variable temperature of the medium.

Central-station men are constantly giving out data showing the excess of the steam required for power over that required for heating, and using it as an argument for making contracts for central-station current. They are correct in some respects and their argument should be met by modifying the heating system as indicated in this paper rather than by reducing the engine economy to suit the heating system.

Due to its temperature range hot water is acknowledged, from a sanitary and economic standpoint, as the best heating medium, and in the proposed arrangement no greater radiation is necessary than for vacuum steam heating. The present system requires expensive pipe galleries and a 20-in. main dividing into an 18-in. for the main building and a 10-in. main for the tower. Large risers are required at each pilaster, to say nothing of the loss of space due to furring into the room to conceal them. The covering of mains and risers is an item as expensive as the piping.

In this particular building a condensing apparatus is provided at considerable expense in operation and first cost merely to reduce the appearance of the exhaust steam on the roof. This apparatus would be entirely inadequate to produce any vacuum on the engines even if the piping system could be made air-tight, which would be next to impossible on so large a system.

The description states that all returns are brought to a vacuum pump. If the returns from the upper stories were reduced in size the falling water would produce ample vacuum. It would be possible with a rotary air pump to return all condensation from the tower by gravity to the boilers direct. The pump, motor driven in the upper stories, would not be required to handle any water at all. If the twenty-ninth floor was 350 ft. from the water level of the boilers the head would be equivalent to 150 lb. pressure.

The direct radiation is given as 104,000 sq.ft., which will be used throughout this discussion, and 178,000 cu.ft. of air are required for ventilation, this amount being heated from the outside temperature to 70 deg. Two comparisons of steam and hot-water heating will be made, one including ventilation and the other without the ventilation. In the latter case 10 per cent. will be added the direct radiation to make up for the elimination of the air supply. This method is followed, as few of these buildings have provision for extensive ventilation and it is desired to make the comparison as broad in its application as possible.

For air supply and exhaust the total air handled is

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given at 417,000 cu.ft. per min., and assuming that 1500 cu.ft. will require 1 hp., 279 hp. or about 200 kw. will be the power load for these motors. For the power load without ventilation 150 kw. will be deducted. Table 4 gives the number of hours for each assumed load for the year with and without ventilation and therefore the total kilowatt-hours. The data were assumed partly from the units installed and the power loads given and are intended for the condition when the building is well occupied. A complete shutdown of 2 to 3 hr. is provided at night, which will deduct about 1000 hr. from the total period of operation. The load factor is given as 32 per cent. when ventilation is included and 27 per cent. without. The holiday and night load in winter may be disregarded as the heating at all times will require more steam than would be furnished by the power load. The fresh-air supply is only considered to be in operation during the 1545 hr. in winter and 1100 hr. in summer, the night-heating load including only the direct surface. The above table of hours was made up from the weather-bureau reports and the calendar; and allowances made for the half holiday Saturday and Sundays, with a 10-hr. working day.

Figs. 1 and 2 give the general arrangement of piping and mains for the main building and tower, the heavy lines indicating the lower section and the lighter lines the upper section. The heaters filled in on Fig. 1 are on the fifteenth floor while those in dotted lines are in the basement. The hot-water system is thus divided into four sections. All connections to exhaust heaters would be made from the main exhaust to the roof. This main would require an automatic relief valve at the top and would have to be made air-tight, although not over 23 or 24 in. maximum of vacuum would be carried, as in summer this line, except for relief purposes, would be shut off.

Each riser has two returns and one supply. There are four supplies to each section in Fig. 1 with a 1¼-in. or

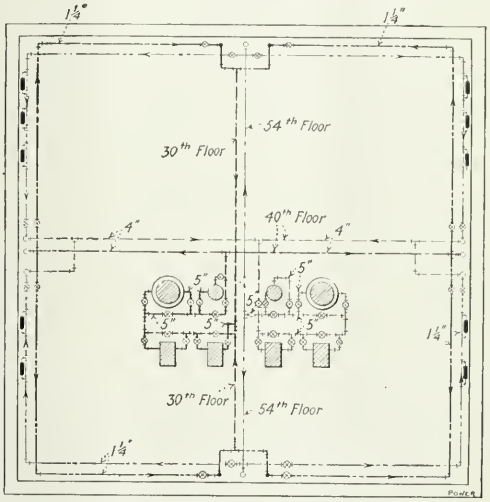


FIG. 2. PLAN OF HEATER AND PUMP CONNECTIONS

1½-in. pipe along the base at each floor from which the radiators are shunted. Each of these lines will have up to 700 sq.ft. of surface and be uncovered. A valve at each end and a permanent drawoff so subdivide the heating system that without interference with the operation of the remainder, only a comparatively small section need be drawn off at one time.

This arrangement brings a supply for the lower section and return from the upper section in the fifteenth-floor corridor, a 5-in. supply for the upper system in the roof space and a 5-in. return in the basement or sub-basement for the lower section. The largest main for the upper section would be 7 in., for the lower section with the indirect, 10 in., and the supply for both sections in the tower would be 5 in. The heaters for the tower would be at the fortieth floor with a similar arrangement of mains.

TABLE 1. DAY HEATING AND POWER WITH VENTILATION (1545 HR.)

Outside Temp. Periods A	Hours Each Period B	Per Cent. Max. Load C	Vacuum In. D	Steam Rate 500-Kw. Turbine E	Lb. Steam per Hr. for Heatiog, 40,000 × Col. C. F	Kw. Load to Balance Heatiog F ÷ E G	Total Probable Load on Red. Vac., Kw. H	Heatiog Steam per Hour from Power, lb., H × E I	Heating Steam for Each Period, lb., I × B J	Total Kw.-Hr. on Heating H × B K
0—10	10	92	0	42	36,000	876	900	37,800	378,000	9,000
10—20	50	82	6.4	38	32,800	863	900	34,200	1,710,000	45,000
20—30	205	72	11.5	34.5	28,800	834	900	31,050	6,365,250	184,500
30—40	500	62	17	30.2	24,800	821	900	27,180	13,590,000	450,000
40—50	350	51.7	22	26.5	20,680	780	850	22,525	7,883,750	297,500
50—60	430	38	26	22.5	15,200	676	750	16,875	7,256,250	322,500
									37,183,250	1,308,500

TABLE 2. NIGHT HEATING WITH HOT WATER, DIRECT RADIATION ONLY

Outside Temp. Periods A	Hours Each Period B	Av. Temp. Water Deg. F. D	Temp. Water Less 70° E	Lb. Steam per Hr. $\frac{104,000 \times 1.7}{1000}$ = 176.8 × Col. E F	Steam for Each Period Lb. B × F G
0—10	56	200	130	22,984	1,287,104
10—20	214	190	120	21,216	4,540,224
20—30	624	176	106	18,741	11,694,384
30—40	971	163	93	16,442	15,965,182
40—50	781	143	73	12,906	10,079,586
50—60	354	122	52	9,200	3,256,800
Total....	3000				46,823,280
				10 per cent.	4,682,328
				Total,	51,505,608

Each heater room would be carried through two stories with a space of about 20x10 ft. This could be found adjacent to the traction elevator machines. All pumps would be motor driven and arranged as shown. All heaters, both live and exhaust steam, on the fortieth floor, and the live-steam heaters on the fifteenth floor, would be arranged to return the condensation to the boilers by gravity. Possibly a dry-air pump may be needed for the exhaust heaters on the fortieth floor, but the exhaust heater on the fifteenth floor would be operated in conjunction with the condensing apparatus.

This arrangement of mains will eliminate the pipe galleries entirely and may be likened to a system having the mains running vertical with the pipes corresponding to the risers horizontal. In Figs. 1 and 2 two lines are shown, but they represent one for the upper and one for the lower section, there being only one at each floor in

any case. The temperature of the heating medium will be regulated in all cases by varying the vacuum and can be done entirely from the basement. Only eight pilasters are required to be furred and the risers will be 5 in. reducing to 2 in. Covering is necessary only on the horizontal mains, heaters and perhaps the vertical risers. All runouts, 1½ and 1¼ in. may be left uncovered, concealed or exposed as desired. They may be used for heating surface as the water temperature is changed to suit outside weather conditions, while the steam system has a nearly constant temperature for all surface turned on.

The cooling tower for 1000 kw. capacity would take a space in the basement or upper floor of 20 ft. in height and two diameters of 18 ft. This could not be placed on the roof as the head would be too great for the condenser and circulating pumps, although not impossible. It could be rigged in conjunction with the outlet for the exhaust ventilation which would reduce the size of cooling tower and cost nothing for air circulation. Its location might be in the basement with a flue leading to the roof.

All water for the hot-water service, air washing and that necessary for flushing closets could be taken from the circulating line to the cooling tower, thus reducing the city water necessary for condensing purposes by a considerable amount. A driven well of small capacity would also answer even if the water was unfit for feed purposes. These operations combined would reduce the water bill appreciably. The turbines and condensers would occupy only about one-quarter of the space provided for the reciprocating engines, although on the whole the total space occupied by the generating units and hot-water condensing equipment will be about the same as for the engines and steam system. The required space, however, could be in less valuable sections of the building, such as spaces adjacent to corridors or elevators.

With a transmission of 1.7 B.t.u. per sq.ft. per deg. difference, Table 2 gives the steam for hot-water night heating, with the direct radiation only, as 46,823,280 lb. for 3000 hr. Adding 10 per cent. to this gives as the steam requirements for the hot-water system without ventilation 51,505,608 lb. for the same interval. The load on the steam system will be taken at 24,000 lb., and 26,400 lb. per hr. with and without the ventilation and with a load factor of 75 per cent., which is low. Thus

$$24{,}000 \times 0.75 \times 3000\ hr. = 54{,}000{,}000\ lb.$$
$$26{,}400 \times 0.75 \times 3000\ hr. = 59{,}400{,}000\ lb.$$

Table 1 gives the heating load on the hot-water system with ventilation and the steam consumptions on a 500-kw. turbine with an hourly load that will exactly balance the heating for 1545 hr. The maximum load days with ventilation is as follows:

Direct Rad.:

$$104{,}000\ sq.ft. \times 1.7\ B.t.u. \times (210 - 70) = 24{,}752{,}000\ B.t.u.$$

Air supply:

$$\frac{138{,}000\ cu.ft.}{50\ cu.ft.} \times 60\ min. \times 70\ deg. = 14{,}952{,}000\ B.t.u.$$

$$39{,}704{,}000\ B.t.u.$$

The maximum load will be taken as 40,000 lb. of steam and percentages used in Table 1 give the proportion for each outside period and length of time. A summary of Table 1 is that 1,308,500 kw.-hr. are obtained from 37,183,250 lb. of steam for 1545 hr.

TABLE 3. DAY HEATING AND POWER WITHOUT VENTILATION (1545 HR.)

Outside Temp. Periods	Hours Each Period	Per Cent. Max. Load	Vacuum In.	Steam Rate 500-Kw. Turbine	Lb. Steam per Hr. for Heating, 27,000 × Col. C.	Kw. Load to Balance Heating F ÷ E	Total Probable Load on Recd. Vac., Kw.	Heating Steam per Hr. from Power, lb., H × E	Heating Steam for Each Period, lb. I × B	Total Kw.-Hr. on Heating H × B
A	B	C	D	E	F	G	H	I	J	K
0—10	10	92	0	42	24,840	591	650	27,300	273,000	6,500
10—20	50	82	6 4	38	22,140	582	600	22,800	1,140,000	30,000
20—30	205	72	11 5	34.5	19,440	563	600	20,700	4,243,500	123,000
30—40	500	62	17	30.2	16,740	554	600	18,120	9,060,000	300,000
40—50	350	51 7	22	26.5	13,950	527	550	14,575	5,101,250	192,500
50—60	430	38	26	22.5	10,260	456	500	11,250	4,837,500	215,000
									24,655,250	867,000

Table 3 gives the same data for a hot-water system with no ventilation. The result here is 867,000 kw.-hr. for 24,655,250 lb. of steam. The heating systems of these buildings are operated continuously in most cases as it is desirable to keep the system free from air, as well as to avoid the expense of heating up in a short space of time. As a result radiators are left turned on and windows opened due to overheating, thus increasing the heating load. All the water has to be handled by vacuum pumps and boiler-feed pumps at some expense during periods of power load when a surplus of exhaust steam is available.

TABLE 4. POWER LOADS

Periods	Total Hours Each Period	Hours Service Each Period	Power Load with Ventilation: Kw. Load	Power Load with Ventilation: Total Kw.-Hr.	Power Load with Ventilation: Kw.-Hr. When Power Is in Excess Heating	Load without Ventilation: Kw. Load	Load without Ventilation: Total Kw.-Hr.	Load without Ventilation: Kw.-hr. When Power Is in Excess Heating
Peak load winter	600	1545	1300	780,000	1,725,000	1150	690,000	1,493,250
Average day load winter	945		1000	945,000		850	803,250	
Holiday and night load winter heat in excess power	3491	3000	300	900,000		250	750,000	
Summer day load	1100	1100	900	990,000	1,592,000	750	825,000	1,337,000
Summer night load	2310	1800	300	540,000		250	450,000	
Summer holiday load	310	310	200	62,000		200	62,000	
Totals	8756	7755		4,217,000			3,580,250	

$$\frac{4{,}217{,}000}{8756 \times 1500} = 32.1\%\ \text{load factor} \qquad \frac{3{,}580{,}250}{8756 \times 1500} = 27.26\%\ \text{load factor}$$

The gravity return of condensation on the hot-water system and ease of regulation of the heating medium does away with these losses, but no credit is allowed in the operating expense.

The hot-water system will lend itself to intermittent operation easier than the steam system, as all that is necessary is to turn steam on the heaters and start the pumps. The turbines require no cylinder oil, thus eliminating all muffler tanks, pumps, receivers and oil-separating apparatus on the main units.

For different vacuums the steam consumption on the turbine is given in Tables 1 and 3. No work is required of the condenser further than regulating the vacuum and preventing the heating medium from becoming overheated. For the reciprocating engine 35 lb. per kw.-hr. is taken as the steam consumption, and 24 lb. for the turbine under 27 to 28 in. of vacuum.

From Tables 1, 3 and 4 it may be seen that from 300 to 500 kw. can be operated at full vacuum over a large part of the time. In Table 1, 900 kw. is required for heating under partial vacuum while Table 4 gives 1000 to 1300 kw. as the power load. In Table 3 it is shown that 600 kw. is required for heating while 250 to 550 kw. could be operated on full vacuum.

For circulating the water in the hot-water system, 10 hp. will be required for each of the tower systems, 50 hp. for the lower section with the ventilation and 30 hp. for the upper part of the main building, making 100 hp. in all, or 75 kw. Nothing is lost in using the power to circulate the water as the mechanical work is all returned in heat, due to friction. The pumps work against only the friction head, due to the velocity of the water; and the exhaust is utilized in the heater. It is, however, live-steam operation when there is a surplus of steam from other sources. To make the comparison conservative the entire pumpage for the water system will be charged and no allowance made for the steam used by the vacuum pumps during the same period on the steam system, although they use about 120 lb. per hp.-hr. The pumpage, however, will be charged at the full vacuum rate of 24 lb. per kw.-hr. At night the cost of pumping will be nothing, due to an inadequate supply of exhaust steam. The day steam for pumping would then be

$$1515\ hr. \times 75\ kw. \times 24\ lb. = 2{,}781{,}000\ lb.$$

of steam. In charging the water for the condensing system a pound of water will be used per pound of exhaust steam condensed at a cost of $1 per 1000 cu.ft. The loss on the steam system will be all that is not required for heating, as it will go to the atmosphere.

In Table 4 the kilowatt-hours of power for the winter day load is given as 1,725,000 and for the total summer load as 1,592,000. The rate per kilowatt-hour for the engines was previously given as 35 lb., so that the total steam consumption would be

1,725,000 × 35 =	60,375,000 lb.
1,592,000 × 35 =	55,720,000 lb.
Total	116,095,000 lb.

A charge of $3.50 will be allowed for fuel, ash handling, etc., and an evaporation of 8 lb. of water per pound of coal. Then

$$\frac{116{,}095{,}000}{8 \times 2000} = 7256\ tons$$

Night heating on direct radiation only for 3000 hr. will amount to

$$24{,}000 \times 0.75 \times 3000 = 54{,}000{,}000\ lb.$$

$$\frac{54{,}000{,}000}{8 \times 2000} = 3375\ tons$$

The water used may be totaled up as follows:

	Pounds
For winter day power load	60,375,000
Heating (1545 hr. at 75 per cent. of 40,000 lb. per hr.)	46,350,000
Difference	14,025,000
Summer load	55,720,000
Total	69,745,000

Reducing the above total to cubic feet and deducting 10 per cent. for feed gives

$$\frac{69{,}745{,}000}{62.5} = 1{,}115{,}920\ cu.ft.$$

$$1{,}115{,}920 - (0.10 \times 1{,}115{,}920) = 1{,}004{,}328\ cu.ft.$$

At $1 per 1000 cu.ft. the water bill would amount to $1004, for the exhaust steam wasted to the atmosphere. The total charge for coal and water would be:

7256 tons at $3.50	$25,396
3375 tons at $3.50	11,812
Water	1,004
Total	$38,212

Referring to Tables 1, 2 and 4 the cost of coal and water for the hot-water system with ventilation may be figured in much the same way. For the winter day load it is shown in Table 1 that there are 1,308,500 kw.-hr. on the heating which require 37,183,200 lb. of steam. Then as the total load for this period is 1,725,000 kw.-hr., steam from

$$1{,}725{,}000 - 1{,}308{,}500 = 416{,}500\ kw.\text{-}hr.$$

will go to the condenser and cooling tower. The total weight of steam will then be

	Pounds
1,308,500 kw.-hr.	37,183,200
416,500 kw.-hr. at 24 lb.	9,996,000
1,592,000 kw.-hr. at 24 lb. (summer load)	38,208,000
115,875 kw.-hr. at 24 lb. (pumpage)	2,781,000
Total	88,168,200

$$\frac{88{,}168{,}200}{8 \times 2000} = 5510\ tons$$

From Table 2 the steam for night heating amounts to 46,823,280 lb. In coal this would require

$$\frac{46{,}823{,}280}{8 \times 2000} = 2926\ tons$$

Water for the cooling tower, pound for pound, will amount to

	Pounds
416,500 kw.-hr. at 24 lb.	9,996,000
1,592,000 kw.-hr. at 24 lb. (summer load)	38,208,000
115,875 kw.-hr. at 24 lb. (pumpage)	2,781,000
Total	50,985,000

$$\frac{50{,}985{,}000}{62.5} = 815{,}760\ cu.ft. = 8816$$

Then, as before, the total charge for coal and water would be

5510 tons at $3.50	$19,285
2926 tons at $3.50	10,241
Water	816
Total	$30,342

The same computations are now made for the steam and hot-water systems without ventilation and allowing 10 per cent. more direct surface. From Table 4 the total weight of steam for the steam system will be

	Pounds
1,493,250 kw.-hr. at 35 lb	52,263,750
1,337,600 kw.-hr. at 35 lb	46,816,000
Total	99,079,750

$$\frac{99{,}079{,}750}{8 \times 2000} = 6192\ tons$$

Night heating on direct radiation for 3000 hr. at 75 per cent. load factor will amount to

$$26{,}400 \times 0.75 \times 3000 = 59{,}400{,}000\ lb.$$

$$\frac{59{,}400{,}000}{8 \times 2000} = 3712\ tons$$

The water is figured as in the previous case.

	Pounds
For winter day power load	52,263,750
Heating (1545 hr. at 75 per cent. of 26,400 lb.)	30,591,000
Difference	21,672,750
Summer load	46,816,000
Total	68,488,750

$$\frac{68{,}488{,}750}{62.5} = 1{,}095{,}820\ cu.ft.$$

Deducting 10 per cent. for feed leaves 986,238 cu.ft., giving $986 as the cost of the exhaust steam wasted to the atmosphere.

The total coal and water costs would then be

6192 tons at $3.50	$21,672
3712 tons at $3.50	12,992
Water	986
Total	$35,650

Following are the data for the hot-water heating system without ventilation. According to Table 4 the total winter day load is 1,493,250 kw.-hr.; from Table 3 the kilowatt-hours on heating are 867,000 and require 24,655,250 lb. of steam. Then

	Pounds
1,493,250—867,000 kw.-hr. at 24 lb.	15,030,000
867,000 kw.-hr. (heating)	24,655,250
1,337,600 kw.-hr. at 24 lb. (summer load)	32,102,400
Pumpage, same as before	2,781,000
Total	74,568,650

$$\frac{74,568,650}{8 \times 2000} = 4660 \text{ tons}$$

with hot water and condensing apparatus. Considering only the day operation the saving would be as follows:

	Coal Tons	Water 1000 cu.ft.	Cost Fuel	Total
Steam with vent	7256	1004	$25,396	$26,400
Water without vent	4660	799	16,310	17,109
Saving	2596	205	$9,086	$9,291
Per cent.	35.8	20	35.8	35.2

Engineers quite generally recommend that as the exhaust steam is available from the power load, it may be used for ventilation without cost, which is not the case under condensing conditions. It, however, is not the purpose of this article to suggest the inadvisability of ventilation, but that it should be properly charged for.

The initial costs of the two systems would be in favor of the water system with the turbine equipment. The use of reciprocating engines would not change the percentage of saving, but the initial cost would be greater as well as the required space. The saving due to the use of condensing equipment is 24 per cent., and is not affected appreciably by the night heating load as at the time the exhaust steam is insufficient.

TABLE 5. SUMMARY OF RESULTS

Hot Water Condensing vs. Steam Noncondensing with Ventilatioo

	Coal Days Tons	Coal Nights Tons	Water 1000 cu.ft.	Cost Coal Days	Cost Coal Nights	Cost Water	Total Cost
Steam	7256	3375	1004	$25,396	$11,812	$1004	$38,212
Hot water	5510	2926	816	19,285	10,241	816	30,342
Difference	1746	449	188	$6,111	$1571	$188	$7870
Per cent. saving	24.1	13.3	18.7	24.1	13.3	18.7	20.6

Without Ventilation

	Coal Days Tons	Coal Nights Tons	Water 1000 cu.ft.	Cost Coal Days	Cost Coal Nights	Cost Water	Total Cost
Steam	6192	3712	986	$21,672	$12,992	$986	$35,650
Hot water	4660	3219	799	16,310	11,266	799	28,375
Difference	1532	493	187	$5,362	$1,726	$187	$7,275
Per cent. saving	24.7	13.3	19	24.7	13.3	19	20.4

Cost of Ventilation on Both Systems

	Steam Noncondensing Coal Days Tons	Water 1000 cu.ft.	Cost Fuel	Cost Water	Total Cost		Hot Water Condensing Coal Days Tons	Water 1000 cu.ft.	Cost Fuel	Cost Water	Total Cost
With	7256	1004	$25,396	$1004	$26,400	With	5510	816	$19,285	$816	$20,101
Without	6192	986	21,672	986	22,658	Without	4660	799	16,310	799	17,109
Difference	1064	18	$3,724	$18	$3,742	Difference	850	17	$2,975	$17	$2,992
Per cent.	14.6	1.8	14.6	1.8	14.2	Per cent.	15.4	2.1	15.4	2.1	14.9

In Table 2 the steam for night heating is given as 46,823,280 lb. Adding 10 per cent. for the increased radiation makes this 51,505,608 lb. Then

$$\frac{51,505,608}{8 \times 2000} = 3219 \text{ tons}$$

Water for the cooling tower is as follows:

	Pounds
1,493,250—867,000 kw.-hr. at 24 lb.	15,030,000
1,337,600 kw.-hr. at 24 lb. (summer load)	32,102,400
Pumpage	2,781,000
Total	49,913,400

$$\frac{49,913,400}{62.5} = 798,614 = \$799$$

Adding the coal and water costs, as in the previous cases, gives the following total:

4660 tons at $3.50	$16,310
3219 tons at $3.50	11,266
Water	799
Total	$28,375

Table 5 gives a summary of the data and shows a saving of about 20 per cent. in the cost of coal and water in favor of the hot-water system. Undoubtedly the night operation on the hot water as against steam will show a much larger saving in practice. As the ventilation is not operative except during day periods, it would be of interest to see what it actually costs over direct radiation

The results of the analysis show a reduction in necessary boiler power of 20 to 25 per cent., or at least 464 hp. A total of 2000 hp. would give as large reserve power as the present system with 2464 hp. The cost of piping and pipe covering on the water system would be considerably lower, notwithstanding that a supply and return of the same size are required on the water system. This difference will be assumed to be $5000 in favor of the hot-water system. The muffler tanks, vacuum pumps, oil-separating apparatus on the steam system are unnecessary with hot water and are included in the $5000 item.

Steam System		Water System	
1500 kw. in compound engine and generators of 100 r.p.m at $35 per kw. with foundations	$52,500	1500-kw. turbines and generators at $20	$30,000
2464 hp. in boilers at $20	49,280	Cooling tower and condensers, 1000 kw. at $20	20,000
Excess cost of piping and covering over water system	5,000	Heaters and pumps in hot-water system	15,000
3000 vacuum valves at $4	12,000	2000 hp. boilers at $20	40,000
		Incidentals and misc. items	4,000
	$118,780		$109,000

The above shows a conservative difference of $9780 in favor of the water system in cost of installation. The 20 per cent. in operating expense, amounting to $7800 for this particular building for fuel and water, if capitalized at 5 per cent., a large net income for most buildings of this class, would mean an equivalent reduction in investment of $156,000.

EDITORIALS

Giving the Central Station an Opening

In a large building in a Southern city, an isolated plant had been giving such poor service that the company seriously considered shutting it down and purchasing its current. A consulting engineer was called to thoroughly investigate the plant and make a report of its condition. The results obtained by the engineer showed an unusual lack of care and waste in the operation of the plant. It is small wonder that a change was contemplated, for the conditions existing would indicate that a cheaper rate could be obtained from the central station.

It goes without saying that a plant requires some engineering ability and care in its operation and, naturally, the equipment must be kept in good operating condition. Good results cannot be expected without this attention, and the engineer who allows a plant to deteriorate and get into poor condition only gives the central station an opportunity to oust him out of his job.

It appears that the boilers were in fair condition as to iron work, but the settings were leaky and required considerable attention. The firebrick in the furnace was burned out in a number of places and the stoker grates needed repairs, as a good deal of coal dropped through and large quantities of cold air rushed through the openings, reducing the efficiency of the boilers. The engines and dynamos were in good condition, but the feed-water heater was so small that a great deal of return hot water from the heating system was lost in the overflow.

In a twenty-four-hour test of the plant it was found that six pounds of coal was required to produce a horsepower-hour, or eight pounds per kilowatt-hour. This coal contained 13,566 B.t.u. per pound, 13.28 per cent. ash and 3.14 per cent. sulphur. It is not an enviable record, and much better results might have been obtained with the plant in good condition. The cost of the elevator service also proved to be excessive. Steam elevator pumps were used and a change to electrically driven pumps, using the same pressure tank, was recommended.

An adjacent building was supplied by the plant, with steam for heating. Upon investigation it was found that the heating system was wasteful and inefficient. In the first place, the pipe leading from the plant through the alley was entirely bare at a certain place, and the rain water falling on the pipe condensed a great deal of steam. The balance of the pipe was laid in an iron water pipe, with scarcely any air space between the two, and both pipes were inclosed in a trench cut in the rock. The waste of heat in this underground section of the supply main may be readily imagined. A one-pipe gravity return system was installed in the building, and this was not properly put up. Such a system should have the radiators set and the pipes connected so that the water can drain out along the bottom of the radiators and follow the pipe downhill to the return pipe, so that there will be no opportunity for pockets. Instead of this, numerous places were found where the steam feeder pipes tilted the wrong way, causing the water to stand in the pipes and necessitating the use of high-pressure steam. A method of properly draining the radiators was suggested so that it would be possible to heat the building with exhaust steam at not over three pounds pressure in the coldest weather, in place of live steam now used at twenty-nine pounds in the boiler room and reduced to nine pounds in the basement. Numerous other defects of minor importance were also pointed out.

With such conditions existing, it is small wonder that the management was dissatisfied with the results. Even with central-station current it would be necessary to remodel the heating system, repair the boiler settings and grates so that steam will be supplied efficiently for heating and substitute electric-driven pumps for the steam pumps now operating the elevators. But with all this done the plant would be in good condition and should be able to generate current cheaper than the central station could supply it. So, in either case there is but one remedy by which results may be bettered, and that is, put the plant in shape and keep it in the pink of condition.

❖

Working with the Specialist

The ever increasing cost of fuel accounts for the growing disposition of owners to subject their power plants to scientific examination to discover any possible way to increase efficiency and effect economy. The fact that the operating engineer himself has been able to make certain tests, compile figures from these tests and make some improvements, will not in many cases avert the inspection of the plant by the consulting engineer. Owners have come to feel about their power plants somewhat as a parent feels about a child who has been ailing for a long time—the family doctor may be treating the case rightly, but it is safer to have a specialist look the child over, even if he only confirms the regular physician's diagnosis.

So the plant owner is calling in the specialist, the consulting engineer, to make a scientific investigation of facts and conditions with a view to possible improvement. Very often his report simply confirms the operator's view, but whether it does or not it is as much an advantage to the operating engineer as to the owner and he would indeed be foolish who opposed any such examination. If the operating engineer is uptodate, he welcomes it because it will vindicate and strengthen him in his position if he has been doing things just right, or it will discover and remove any weak spots in his practice.

For this reason the operators ought to, and can well afford to, assume the most friendly and helpful attitude toward the consulting engineer whom the management has invited into his plant. The consulting engineer is not a rival, but a colleague with some superior advantages that help bring success in the effort to remove weaknesses in his plant and add strength and efficiency to it. The

operator who best serves his own interests, as well as those of his employer, will take the greatest possible advantage of this coöperation. He will cultivate the friendship of the consulting engineer, will take him into his confidence and put candidly before him any questions and problems in the plant operation which have puzzled him. It is his privilege to do this, for the consulting engineer's time and knowledge are paid for by the plant owner. He certainly should assist as much as possible in making any tests, and unless he understands these tests thoroughly he should not hesitate to ask questions. What he learns now may prevent his showing ignorance at a later and more critical time. Thus he may learn to judge of and advise upon the selection of competent specialists for the owner to engage to make subsequent examinations.

Meeting the outsider half-way will result in benefit to the operator and probably render the examination of his plant very much more successful than it could be without his cordial help.

Incidentally the indorsement which any fair-minded consulting engineer will give a competent operating engineer will have more influence with the employer than all the unsubstantiated arguments that the engineer could advance for a raise in salary. From all considerations, it appears not only the philosophical thing, but positively and practically the most advantageous thing to do, for all concerned, for the operating and consulting engineers to work with, not against, each other. Logically, their services are not competitive but complementary.

Concealing the News

Most people are interested in reading the news. It is almost a fundamental habit, in this country especially, acquired long before maturity is reached. Now here is the inconsistency—great as is our avidity to get the news we instinctively withhold such news as pertains to ourselves. Unless it is in connection with something to which honor attaches we have a horror of having our names in the papers.

This can be understood when one has committed a crime or done something scandalous, but why in the name of all that is reasonable does anyone deny information regarding a boiler explosion, flywheel disaster or anything of that kind?

We wish we might bring home very strongly to our readers the idea of coöperation in this matter of news so that they would not conceal news when it concerns their plants. If they would only regard it a duty they owe to their fellow engineers in return for the information they get of others, they would change their attitude toward the news seekers from the papers.

Some of our readers are accommodating and courteous when approached for news by our representatives. We are indeed grateful to them and even more so to those others who anticipate our desire for news and on their own initiative send items regarding their own plants or plants in their locality.

Regrettably there is this large class of conservatives who cannot bear to think of being "written up." If an accident has happened for which the engineer was responsible he naturally shrinks from publicity. Even then he should be broad gage enough to be willing that his mistake be made a warning to others. When the accident is one due to circumstances over which neither the engineer nor any of his assistants had any control it is foolish to imagine that an account of it in the papers will reflect any discredit on him.

We feel we have a stronger claim on such news than the daily papers because our motive in writing up accidents is that it may help other engineers avoid the same kind, if the cause has been discovered. There is no purpose of exploiting these things for the sake of notoriety or sensation.

POWER seeks to cover all reachable accidents that may contain a lesson or in any way add to the knowledge of other engineers to promote the safety of those engaged in the industry, as well as the public at large. Now let us have everybody's help.

Interrupted Service

The experience of those Staten Island industries which were dependent on the Richmond Light & Railway Co. for power and which were completely tied up for five days as a result of the recent boiler explosion, serves as a forceful answer to certain arguments of central-station adherents.

As far as the lighting is concerned, its absence was an inconvenience, but the residents have become so accustomed to interrupted service with every summer thunder storm that their attitude has changed from one of protest to mere tolerance. With the power customers the problem was far more serious, however, and those industries which possessed private plants were indeed fortunate.

The accident was most deplorable, whatever the contributing causes, and in spite of what appears to have been unnecessary delay in the resumption of service, the incident serves to point out the undesirability of "putting all the eggs in one basket."

Within the legitimate field of a public utility the community's interest is usually best served by a single company and seldom has cut-throat competition proved desirable. At the same time, in return for this monopoly, the citizens have the right to expect certain guarantees of service, one of which is sufficient reserve capacity, properly distributed, to guard against just such exigencies as the present.

The Loading of Boilers

For emphasis, we repeat what J. E. Terman has said on another page regarding the loading of boilers:

> When horses are hitched together, the draft gear is usually arranged so that it will be necessary that all pull alike, but the average steam engineer will hitch from two to ten or more boilers together without apparently giving the matter much thought as to whether each will carry its proper share of the load or not.

And a little farther on:

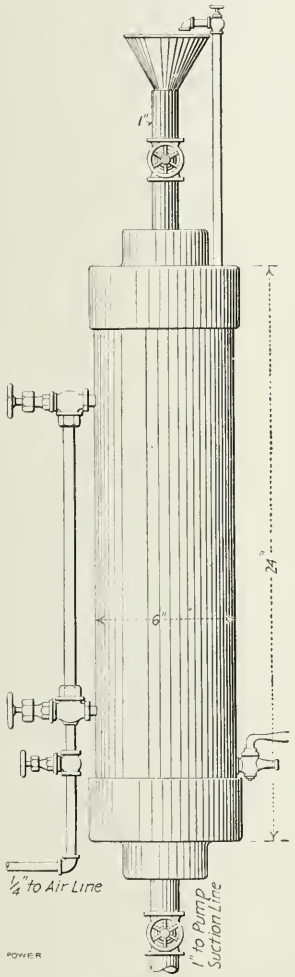
> When two or more boilers are operated on a load that approximates their combined capacities, the efficiency will be maximum when the load is distributed between them in proportion to their capacities, and the efficiency will be less the greater the inequality in the distribution of the load.

Of course, most engineers know all this perfectly well. So do most small boys know that if they eat too many green apples they will have cramps, but they keep on eating green apples.

READERS WITH SOMETHING TO SAY

Another Compound Feeder Made of Pipe

We have in use a boiler-compound feeder consisting of piece of 6-in. pipe 24 in. long, with a plug in each end. At the top there is a 1-in. nipple, a globe valve and funnel for filling, also a ¼-in. vent pipe to allow the escape of air when putting in the compound. At the bottom is a 1-in. pipe with a globe valve connected to the suction line of the boiler-feed pump. A drain cock is also provided. An ordinary water gage-glass is fitted to the side of the reservoir, and at the bottom of this glass is connected a ¼-in. pipe with a needle valve which is connected to a compressed-air line.



Feeder for Boiler Compounds

To operate this feeder close the 1-in. valve in the suction line, also the needle valve in the air line, then open the valve between the funnel and reservoir; the ¼-in. vent is opened also, and in case the air comprsesor should not be running, any water left in the reservoir can be drawn off at the small drain cock at the bottom. If we have air pressure when filling, the air can be turned on and the water is quickly forced into the suction line of the pump, the compound, which is previously dissolved in water, is now poured into the reservoir. Both the valves at the top are closed and the valve in the suction line opened, then the needle valve is adjusted to feed the required amount of compound. Air bubbles rise in the glass and it is possible to accurately judge just how fast the compound is being fed to the boilers by observing these air bubbles.

S. A. Standley.

Fort Wayne, Ind.

Strains in Flywheels

After reading the letter of John F. Hurst, on page 242 of the Aug. 12 issue, and also the letter of Forrest Allen, which preceded it, it appears that an explanation of a few of the simple calculations concerning the estimation of the force expended in producing changes of speed in flywheels, may be of interest.

Mr. Hurst's surmise that engine governors cannot be built to care for the sudden throwing off of all load is, of course, not correct. Thousands of street-railway engines are operating under conditions where a maximum overload is reduced to no load instantly, when the circuit-breakers come out. Such action is often repeated many times a day, and the governors on these engines take care of the speed fluctuations, and without producing any severe strains in the flywheel.

To calculate the energy stored in a rapidly revolving flywheel, it is simplest to consider what the stored energy would be if gravity had acted on the wheel for a sufficient length of time to produce the same conditions of speed as those for which the calculations are to be made. When a body falls from a height, the formula

$$v = gt \qquad (1)$$

expresses the relation between the velocity and time of falling, if we neglect the action of the air. In this formula, v is the velocity in feet per second, t the time of falling, in seconds and g is the acceleration due to the force of gravity, which is about 32.16 ft. per sec. at the sea level. The formula

$$v = \frac{2h}{t} \qquad (2)$$

expresses the relation between the velocity, time and height of fall. If the velocity is known, the time may be obtained by the use of the formula (1); and by using the

result in formula (2), the height of fall is found. It is evident that, if the weight of a body and the height through which it has fallen be known, the stored energy in foot-pounds may be obtained by multiplying the weight in pounds by the fall in feet. Bodies of equal weight and speed (which represents falls of equal height) have the same amount of energy stored in them, so that if we know these two factors for any case the stored energy can be calculated, this is so whether the body is moving in a straight line, as would be the case for a falling body, or a body revolving around a center, as the rim of a flywheel. Considering a practical case of a 500-hp. engine with a 20-ft. flywheel revolving at 80 r.p.m. and with a rim weighing 30,000 lb.; we find by figuring the speed of the rim, that it is running at 83.7 ft. per sec. The amount of energy stored in the rim, expressed in foot-pounds, would be (as explained above) the distance in feet through which it would have fallen to obtain this speed, multiplied by the weight of the rim in pounds.

Using the velocity of 83.7 ft. a second in formula (1), we have,

$$83.7 = 32.16\ t \text{ or } t = 2.6\ sec.$$

Using the value of t just found, in formula (2), we have

$$83.7 = \frac{2\ h}{2.6} \text{ or } h = 109\ feet$$

This indicates that in order to attain the same velocity by falling as when revolving, the rim of the flywheel would have to fall through a space of 109 ft., and it would therefore have stored in it

$$30{,}000 \times 109 = 3{,}270{,}000\ ft.\text{-}lb.\ of\ energy$$

We, therefore, know that without considering friction or any other factors that may affect the result, that there must be put in the rim of this wheel 3,270,000 ft-lb. of energy, to bring it from a state of rest up to a speed of 83.7 ft. per sec.

Assuming that the engine cylinder delivers the same turning effort to the crankpin at all speeds, the average speed of the wheel starting from rest would be 40 r.p.m., or power is stored at the average rate of

$$\frac{500}{2} = 250\ hp.$$

which is

$$250 \times 33{,}000 = 8{,}250{,}000\ ft.\text{-}lb.\ per\ min.$$

and if there were no other work to be done the energy would be stored in the flywheel rim and would revolve the wheel faster and faster. Since it requires the storage of 3,270,000 ft.-lb. of energy to get the rim up to normal speed, it would take

$$\frac{2{,}270{,}000}{8{,}250{,}000} = 0.396\ min. \text{ or } 23.8\ sec.$$

to get this wheel up to normal speed with the throttle wide open and no load on the engine.

The friction of the air in the case of the falling body, and the friction of the air and bearings in the case at the flywheel have not been considered, nor have several other factors that would have a bearing on the actual time it might require to bring a wheel up to speed been considered, but the main retarding influence in most engines is the weight in the flywheel rim and the above calculations show how the amount of this effect can be estimated. It can be readily seen that to start or stop a wheel suddenly means the expenditure of an immense amount of energy, and Mr. Hurst's idea that the speed may become dangerous in a portion of a revolution, is, of course, not correct for wheels ordinarily used on engines. For example, take the case of the wheel just considered and assume that the speed is to be increased 2 per cent. above normal. It would be necessary to store about 133,000 ft.-lb. of energy in the rim to accomplish this change in speed and this would take about $^{65}/_{100}$ of a revolution, if we assume that the entire energy developed by the engine was devoted to speeding up the rim. A 2 per cent. or even a 20 per cent. increase in speed could not be considered dangerous if the normal speed of the wheel was one that could be considered safe. The factor of safety under which flywheels usually operate, is such, that a speed of at least three times the normal speed is required to burst them. Taking the wheel that we have considered above, and assuming that a rim speed of 15,078 ft. per min. would burst it, we find by making the calculations as previously explained, that there would be required stored about 26,200,000 ft.-lb. of energy, or 126 revolutions, at an average speed of 160 r.p.m., to reach the bursting point, or it would require 47 sec. after all the load were thrown off before the wheel would reach the bursting speed. With a fairly good governor no severe strains are likely to be produced in the flywheel by suddenly throwing off load, but the strains that may be produced by suddenly throwing on a heavy load can hardly be estimated. Where the shock is not transmitted directly to the rim of the wheel, as would be the case with water in the cylinder or with a direct-connected engine and generator when a short-circuit occurs, the strains on the flywheel are extremely severe. When water gets in the cylinder, there is usually some portion of the engine frame or wheel broken, as the force expended in these cases depends on the time in which the stored energy in the wheel and other parts of the engine in motion must be cared for.

J. E. Terman.

Hartford, Conn.

Collecting and Reusing Cylinder Oil

The question of reusing cylinder oil seems to deserve little consideration, judging from what little has been said about it. However, we have worked out an idea by which we have effected a 30 per cent. saving in the oil consumption. Since the apparatus is inexpensive a description of it may be interesting.

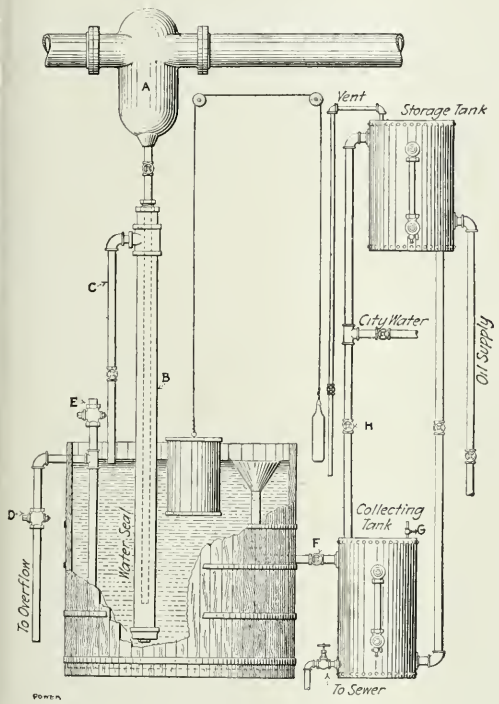
A series of experiments disclosed the following facts: First, that the viscosity of cylinder oil after passing through highly heated spaces, such as steam-engine cylinders, is greatly impaired; that having been gathered with a mixture of steam and water, it is more or less emulsified and will not work in ordinary drop-feed lubricators. It is, however, worth saving for use in pumps, etc.

The illustration shows clearly how the oil is collected and separated in our plant. No attempt has been made to use this oil on a higher class of machinery than direct-acting pumps of moderate speed.

From the oil separator A in the main exhaust line, the mixture of oil and condensate enters first a water seal B made up of 1-in. pipe inserted in a 3-in. pipe, the former open at the lower end. The mixture must rise to another 1-in. discharge pipe C, the top of which is but a short distance below the separator. The oil and water are dis-

charged through pipe *C* into a large open tank in which the oil rises to the top. A skimmer in the form of a funnel is placed in this tank in such a position that the slight rise in the oil level in the tank will cause the oil to flow into the funnel and then to a collecting tank. The surface of the liquid is raised by means of a bulky weight or displacer being lowered into the liquid. The cock *D* in the water drain pipe must be closed when the displacer is lowered into the tank.

To run the tank empty it is necessary only to lower the displacer enough to start the water through the overflow with the cock *E* closed when a siphon will be formed. When the collecting tank is full the inlet valve *F* and



Apparatus for Reclaiming Cylinder Oil

the vent valve *G* are closed and the valve *H* in the 1-in. line to the storage tank is opened. This tank corresponds in size with the one on the floor, but it is located well above the rest of the apparatus and has a return connection to the floor tank so as to allow a more rapid elevation of the oil as it leaves the top of the bottom tank to enter the top of the top tank.

The water runs from the bottom of the top tank to the bottom of the bottom tank. When the oil is all up, the water is run from the collecting tank into the sewer to make room for more oil.

The oil is fed to the pumps by gravity droppers. A larger quantity of this oil must be fed than if first-class oil were used.

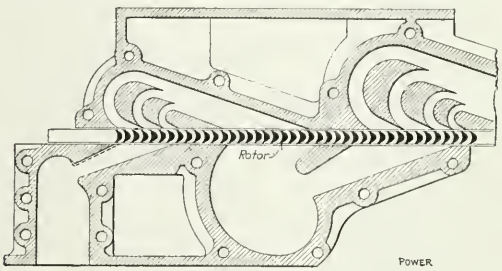
Edward T. Binns.

Philadelphia, Penn.

Turbine Nozzle Too Small

Much trouble was caused through a low-pressure turbine not giving its rated output. With steam at 15 lb. per sq.in. abs., it was supposed to give 300 kw., but we could not get more than this with a pressure of 18 lb. abs. The pump was running at 1480 r.p.m., which was 20 less than called for. The rotor of the turbine was lifted out and all the blades cleaned, and where any were a little "out" they were set back to their original position. But this made no improvement in the running of the turbine.

At last two holes were tapped in the steam line; one of these holes was on each side of the governor which stepped down the pressure for use in the turbine. The gages indicated equal pressures, showing that the governor was admitting steam but that the steam was held in the first nozzle of the turbine. The nozzle was lifted out and made larger, as shown in the illustration; the dotted line showing the original size of the nozzle. We turned down one side of the nozzle to a 20-deg. angle



Partial Section of Turbine

of entry and planed about $\frac{1}{16}$ in. off the opposite side. When the turbine was assembled and steam admitted, it ran 1580 r.p.m. under full load. On applying the load to the turbine we were able to get 400 kw. with an initial pressure of 18 lb. abs. and could easily carry all the load required.

James A. Campbell.

Lowell, Mass.

Power-Plant Vibration

In the article on "Power-Plant Vibration and Methods of Isolation," by Francis H. Davies, in the Aug. 12 issue, the figures regarding minimum and maximum thicknesses of $\frac{1}{8}$ to $4\frac{3}{4}$ in. for cork-isolated plates and also the compression tests given apply to our material "Resilient" plate. This is largely used by the principal underground railways in place of felt and such like material, as pads for rail chairs and railway carriages, and also in building construction, machinery foundations, etc. This is the material, which has been tested to a pressure of 2500 lb. per sq.in. with successful results.

The iron-framed cork foundation plate described by Mr. Davies is called "Bavanite" and is made in a standard thickness of $2\frac{3}{8}$ in. A copy of tests for resilence carried out on these plates is given herewith.

In these tests it will be noticed that the maximum pressure was 210 lb. per sq.in. with a mean compression of 45.9 per cent. of the thickness, returning 5 min. after

e removal of the load to a residual compression of 11.43
r cent. In actual practice we allow a maximum work-
g pressure of 20 lb. per sq.in., and, generally speaking,
is found that the average pressures on the base of con-

COMPRESSION TESTS FOR RESILIENCE OF "BAYANITE"

Test No.	Mean dimensions before test, in. Thick-ness, in	Breadth in.	L'gth in.	Area	Total compression per cent. under following loads. Lb. per sq.in. 35	75	105	140	175	210
	2 375	7 875	7.875	61 75		8 5	25.5	38 2	44 0	45 5
	2 375	7 875	7 875	61 75	4.5	7.8	23 5	38.5	43.3	44.5
	2 375	7 875	7 875	61 75	1.7	6.8	26.5	39 7	44 7	48 7
an	2 375	7.875	7 875	61 75	2 06	7 7	25 16	38 8	44 0	45 9

Residual deformation per cent. after removal of following loads in lb. per sq.in.

105		140		175		210	
At once	5 min. after	At once	5 min. after	At once	5 min. after	At once	5 min. after
7 5	5 0	15 7	8 8	19 3	11.7	21 7	13.3
8 8	4 3	14 0	8 5	18 7	10 8	18 7	12.5
7 3	3 0	12 3	5 8	14.3	7 7	18.0	8.5
m 7 86	4 1	14 0	7 7	14 1	10 6	19 46	11 43

The Royal Engineering Institute, Charlottenburg, 1912.

te foundations rarely exceed 15 lb. per sq.in., thus
ving a factor of safety in the working of the material.

ROBERT B. GREY, Gen. Mgr.,
The British Anti-Vibration & Noise Co., Ltd.
London, Eng.

Analysis of Mr. Chandler's Diagram

It looks to me as though W. E. Chandler has a wrong
ea of which is the expansion line in the left-hand dia-
m of the indicator diagram shown in the Sept. 16
ue. The expansion line of this diagram is the lower
e where one generally finds the exhaust line.
When the piston moves forward with the steam valve
sed there is but little steam in that end of the cyl-
der in which steam was trapped by the exhaust valve
en it closed. This steam soon expands so much that
acuum is created in this end of the cylinder. There
11 lb. steam pressure in the receiver, and when the
essure in the cylinder drops low enough this 11 lb. act-
g on the area of the exhaust valve covering the exhaust
rts overbalances the pressure in the cylinder acting on
top of the valve and also the weight of the valve. The
ve will lift, letting a little steam into the cylinder from
receiver. This causes the expansion to be nearly
aight for a good part of the stroke near the end, as
piston is traveling slower, enough steam leaks in to
se it a very small amount.
When the exhaust valve opens, the steam from the re-
ver rushes in and raises the pressure in the cylinder.
is engine is a tandem compound, and when the ex-
ist valve closes the engine begins the return stroke.
l the low-pressure cylinder is taking steam from the
eiver. This causes the pressure in the receiver to fall
ghtly until the steam valve on the low-pressure cylinder
ses, when the line on the diagram is nearly straight.
w, when the exhaust valve closes, the steam that is in
cylinder is compressed, as shown in the diagram.
hen the engine next starts on the forward stroke this
am expands, but, due to condensing and leakage, the
essure does not follow the compression line but falls
ow it.
The exhaust valve on the head end closes a little ahead
the exhaust valve on the crank end.

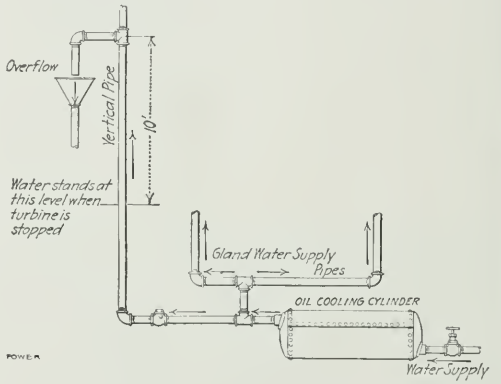
L. A. FITTS.
Greenfield, Mass.

Sealing Glands of Low-Pressure Turbines

In that class of low-pressure turbine which uses water seals to prevent air leaking in where the shaft comes through the case the sealing does not become effective until the turbine has attained considerable speed. As the turbine will not start until there is a vacuum in the condenser, these turbines require auxiliary glands to seal the shaft opening while the vacuum is being built up in the condenser by the air pump or ejector.

There is in the plant of which the writer has charge a turbine of this type which was piped for gland-water supply according to the builders' suggestions, as shown in the sketch. From the start we had considerable trouble getting a vacuum created in the jet condenser; the vacuum would build up momentarily to about 12 in., and then drop back to zero.

A study of the piping will show that as soon as the small amount of water remaining in the standpipe was drawn into the turbine by the vacuum, the standpipe would be fully open to admit air into the turbine and prevent the vacuum being built up. As the auxiliary



PIPING ARRANGEMENT FOR SEALING GLANDS OF TURBINE

glands are outside the centrifugal glands they cannot prevent the inflow of air through the gland water-supply pipes.

A swing check valve A placed in the horizontal pipe leading to the 10-ft. riser will prevent this trouble and facilitate starting in installations having no forced injection line or valve between the turbine and condenser.

Turning on the gland-water supply will also prevent the entrance of air, but is not very desirable because the water flows into the turbine at each end, until the speed is high enough to seal the glands. The cool water flowing over the heated shaft together with the danger of getting water into the oiling system are the objectionable features of this method.

P. L. WERNER.
McKeesport, Penn.

[The sealing glands of condensing turbines should also be carefully watched for scale. Where the sealing water is alkaline and is heated by the shaft, scale will sometimes form.—EDITOR.]

INQUIRIES OF GENERAL INTEREST

Cleaning Grease from Boilers—How may boilers be cleaned of grease deposited in them where surface condensers are used?

N. N.

Coatings of grease can be removed from boilers by using a solution of soda ash and water boiled up in the proportion of about 1 lb. per 10 hp., after which the boiler should be blown off and washed out.

Locating Water Coolers—Is it important to put atmospheric distilled-water-cooling coils, as well as ammonia condensers, for a refrigerating plant, where air or wind can strike them, or might they be put inside of a tower with 12 to 18 in. headroom and only two small windows opening to the outside air, both on the same side of the room?

R. H. R.

Wherever possible, both the open-air condensers and the open-air distilled-water coolers should be placed where the outer air can circulate around them freely. Care should be taken, however, to shade them from the direct rays of the sun. It would not be considered good practice to put this apparatus inside of a tower, such as described, for the air in this tower would very soon become practically saturated with moisture and no benefit would be derived from evaporation.

Safe Flywheel Speed—We have an engine running at 74 r.p.m. with a flywheel 12 ft. in diameter with a 21-in. face and rim 2½ in. thick, cast in two sections. How much faster can the engine be run safely?

J. C. M.

The maximum safe speed for sound cast-iron flywheels is usually taken to be a rim speed of a mile a minute, i.e., 5280 ft. per min. If the wheel is made up in halves or other sections, the lugs, bolts and other fastenings are supposed to be made as strong as the rest of the rim. The breadth and thickness of the rim are immaterial, as the centrifugal force is directly proportional to the weight, and the strength is directly proportional to the size. The wheel being 12 ft. in diameter, its circumference is $12 \times 3.1416 = 37.69$ ft., and with fastenings of sections equal in strength to the rim and the casting sound, the wheel should be safe at a speed of

$$\frac{5280}{37.69} = \text{about } 140 \text{ r.p.m.}$$

Flow of Water—Can the formulas given in the article in the July 1, 1913, issue "Flow of Water in Pipes," be applied to pipes having a diameter of 100 in., and a loss of head of 100 ft. per 100 ft. of pipe?

J. P. Z.

Durand's formulas and chart apply to flow of water in iron pipes up to 12 in. diameter discharging with loss of head up to 10 ft. His article is based on the average of different formulas for the loss of head, etc., in the commercial sizes of iron pipe as quoted by Mr. Evans, July 9, 1912, issue referring to losses in sizes used in hot-water heating. It is hardly probable that the formula which you refer to would hold true as an average extended to pipes 100 in. in diameter especially as the Chezy and other formulas referred to require the use of a constant determined by experiment for each particular case. On comparing actual tests of large pipes (i.e., 36 in. to 100 in. diameter) Darcy's formula has been found to come closer to the average than any for the use of which constants are not established for the case in hand. But no set formula, i.e., one for which constants have not been established for the particular case in hand, can be relied on closer than about 15 per cent. on account of the difference in roughness of pipe surfaces.

Nozzle Discharge Velocity—What would be the velocity of the water discharged through a 1-in. nozzle under a pressure of 75 lb. per sq.in.?

C. A. G.

A pressure of 75 lb. would be equal to a head of $75 \times 2.309 = 173.17$ ft.

The theoretical velocity of discharge in feet per second would be

$$v = \sqrt{64.32 \times 173.17} = 105.5 \text{ ft. per sec.}$$

The average velocity of discharge from a nozzle, taken at the smallest cross-sectional area of the issuing solid stream, i.e., at a few inches beyond the nozzle, would be 95 to 97 per cent. of the theoretical velocity, depending on the smoothness of the nozzles.

(For a "ring" nozzle, the smallest part of the stream becomes reduced to about 65 per cent. of the cross-sectional area of the nozzle, and for a nozzle with a gradual taper and smooth bore, the cross-sectional area will be practically the same as the nozzle.)

A 1-in. nozzle would have a cross-sectional area of 0.7854 sq.in., and a smooth bore nozzle under 75 lb. pressure per sq.in. at the nozzle should discharge

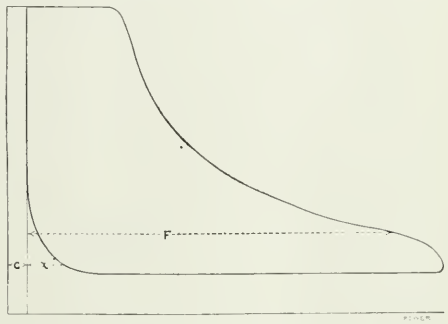
$$105.5 \times 95 \text{ per cent.} \times \frac{0.7854}{144} \times 7.5 \times 60 = 245.98 \text{ gal.}$$

or practically 246 gal. per min. With a 1-in. dia. "ring" nozzle, the discharge should be 65 per cent. as much, viz.: 65 per cent. of 246 = 159.9 gal., about 160 gal. per min., or 62 per cent. of the theoretical discharge.

Steam Consumption—How is the steam consumption of a compound engine calculated from indicator diagrams?

J. A. P.

The same formula is used as for a simple engine and will be understood by reference to the following diagram taken from Low's "Steam Engine Indicator":



$$Q = \frac{13{,}750}{p}\left[(F + c)\,w_f - (x + c)\,w_x\right]$$

in which

- Q = Pounds accounted for per horsepower per hour;
- p = Mean effective pressure, pounds per square inch;
- c = Clearance in fraction of stroke;
- F = Fraction of stroke completed at some point chosen on the expansion line;
- w_f = Weight per cubic foot of steam at a pressure corresponding to the point chosen on the expansion line;
- x = Fraction of stroke uncompleted at some point chosen on the compression line;
- w_x = Weight per cubic foot of steam at the pressure corresponding to the point chosen on the compression line.

A diagram from either cylinder may be used, but the mean effective pressure employed in the formula must be one which would give the equivalent total power if it existed in the cylinder from which the measured diagram was taken. For example, if a low-pressure cylinder diagram is used, to the mean effective pressure for that cylinder must be added the mean effective pressure in the high-pressure cylinder multiplied by the square of its diameter and divided by the square of the low-pressure cylinder diameter. If a high-pressure diagram is used, the low-pressure cylinder mean effective pressure multiplied by its diameter squared and divided by the high-pressure cylinder diameter squared, must be added to the high-pressure cylinder mean effective pressure. In other words, the mean effective pressure in one cylinder corrected for combination with that in the other cylinder is inversely proportional to the squares of the diameters of the respective cylinders. If the strokes in the two cylinders are not equal, which is very rare, correction for that fact would have to be made.

ENGINEERS' STUDY COURSE

Feed-Water Treatment—III

To secure desirable results in treating feed water the antity of compound supplied must be proportioned ording to the amount of scale-forming impurities pres- . To estimate the amount of impurities present neces- ites an analysis of the water. Generally speaking, a ter analysis can only be made by a trained chemist. can be attempted by others, but the results obtained uld in most cases be so inaccurate as to be useless. The gineer can, however, make an approximate analysis ich is of some value in indicating the character of the ter and if the analysis is made with care and the water es not contain impurities that complicate its nature much, the kind and quantity of scale-preventing com- und needed can be estimated.

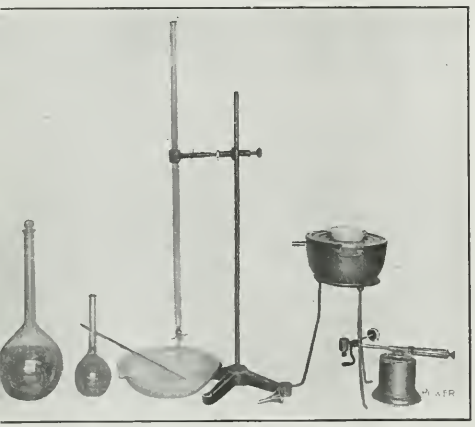


FIG. 1. APPARATUS REQUIRED FOR PROXIMATE WATER ANALYSIS

The following method of approximate water analysis based on that given by John B. C. Kershaw, in "Fuel, ater and Gas Analysis," published by D. Van Nostrand .

TEST APPARATUS

Assuming that the reader possesses the apparatus for aking the proximate fuel analysis, as listed in the May lesson, the following additional equipment, most of ich is shown in Fig. 1, is required for making the oximate water analysis as here outlined:

Copper water bath, 6 in. diam.	$1.50
Measuring flask (200 c.c. capacity)	0.35
Porcelain dish (22 oz. capacity)	1.00
Glass stirring rod	0.10
Burette, graduated in $\frac{1}{10}$ c.c. (50 c.c. capacity)	2.00
Funnel for filling burette	0.10
Support or stand for burette (adjustable)	0.80
Measuring flask (100 c.c. capacity)	0.90
Porcelain dish (about 50 c.c. capacity)	0.15
Glass funnel for filtering (4-in.)	0.20
Package of filter paper (8-in., 100 sheets)	0.35
	$7.45

The following chemical solutions are also required:

2 oz. concentrated solution methyl orange	$0.50
1 liter—one-fifth normal standardized solution hydrochloric acid	1.40
1 liter—one-fifth normal standardized solution sodium carbonate	1.40
2 oz. alcoholic solution phenol-phthalein	0.50
	$3.80

If the reader does not possess proximate fuel-analysis apparatus it will also be necessary to secure a bunsen burner or an alcohol or gasoline lamp (such as is shown in Fig. 1) and an iron tripod or adjustable iron stand for supporting the water bath.

COPPER WATER BATH

The copper water bath, shown on the tripod in Fig. 1, is employed when evaporating a sample of water under conditions requiring a uniform heat at 212 deg. F. The bath is fitted with a lid composed of rings of various diameters so that the vessel containing the sample may be conveniently supported over the boiling water. A vent or spout at the side and just below the top permits the steam to escape without inconvenience to the analyst.

MEASURING FLASK

As the name implies, a measuring flask is used to measure out samples or reagents when accuracy is important. Its neck is small in diameter, and has a fine line around it to which level the liquid to be measured is poured.

BURETTE

The name burette should be familiar to the reader, as we employed one in measuring flue gas when making an analysis with the Orsat apparatus. As may have been surmised, "burette" means measuring vessel. In the present case the burette is employed to measure liquids.

Acids neutralize alkalies and *vice versa.* For instance, water containing a quantity of some acid has certain definite characteristics whereby its acid nature can be recognized. It will corrode or eat away certain metals, say, iron, and it will, generally, change a sensitized paper called litmus paper from blue to red. Now, if a certain definite quantity of alkali is added to this water the latter will lose its acid characteristics—because the alkali has neutralized the acid it contained by a chemical action between them. If more alkali be added so that the water now contains a quantity in excess of that which was required to neutralize the acid, other characteristics will be acquired. A definite quantity of alkali is required to neutralize a given quantity of acid and *vice versa.* For illustration, if a gallon of water contained, say, an ounce of a given acid, hydrochloric, for instance, it would be found that a definite amount of some alkali, say, sodium hydrate, would be required to neutralize this acid.

When the amount of contained acid is known, the amount of the required alkali can be calculated. Hence, when the amount of the acid is unknown, but by experiment the required amount of alkali is ascertained, it is possible to calculate therefrom the quantity of acid neutralized.

This principle is extensively made use of in chemistry. When analyzing water certain chemicals are added to the sample being analyzed and the amount of such chemicals required to produce a certain change is measured as accurately as possible. This is the purpose of the burette; it is made long and of small diameter so that the quantity of liquid contained before and after some has been let out can be measured closely. When a person adds chemicals to a sample by means of the burette and measures the quantity required to produce a certain change in the character of the sample, for the purpose of estimating its original make-up, he is said to titrate the sample. If it is sodium hydrate he happens to be adding he is said to be titrating with sodium hydrate.

When emptying the burette of one compound and filling with another, first rinse the burette with distilled water and then pour in or rinse with a little of the new compound to be used and drain this out again before the main bulk of the new compound is filled in.

Indicators

When titrating a sample of water with a certain chemical it is often necessary or convenient to first put some other compound into the water for the purpose of indicating by change in color when the point of neutralization has been reached. When a compound is employed for this purpose it is called an indicator. Methyl orange and phenol-phthalein are used as indicators when titrating with hydrochloric acid or sodium-carbonate solutions to ascertain alkalinity or acidity.

Hydrochloric Acid Solution, Etc.

The accuracy of results when titrating depends upon the accuracy in measuring the sample, the accuracy in preparing the titrating fluid, the accuracy in reading the amount of titrating solution required and the accuracy in determining the point when neutralization has been effected. As it is important to get the strength of the titrating fluids as nearly correct as possible it is recommended that the one-fifth normal standardized solution of hydrochloric acid and of sodium carbonate be purchased ready made up. This will save bother and trouble and insure a greater accuracy than can be obtained under average conditions where proper facilities for best work are not present.

The bottles containing the solutions should always be kept well stoppered so that the strength will not change due to evaporation.

⁂

What is Probably the Oldest Vessel to be fitted with an internal-combustion motor has just carried out her "maiden voyage under power." She is the "Ceres," built at Salcombe in 1811, and for many years was in the fruit trade in the Western Islands. In 1855 she was purchased by Messrs. Petherick, of Bude, who have just had her installed with a two-cylinder 24-hp. marine heavy-oil engine.—"The Gas Engine."

⁂

Situation for Elevator Inspector—The Chicago Civil Service Commission will hold an examination Nov. 4, 1913, for elevator inspector. Salary, $1440-$1620. Subjects of examination: Special subject, penmanship, arithmetic, experience, report. Duties: Inspects all elevators and other mechanisms, devices and apparatus assigned to him by the inspector in charge, both existing and in process of being erected or installed, together with all the equipment and inclosures thereof, making daily reports to the Commissioner of Buildings regarding condition of same; performs such other duties as may be assigned to him by the Commissioner of Buildings.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

It's been some lively in York village this week, what with Emmy Pankhurst and Tony Comstock, Old Bill Sulzer and Eddie McCall, Jawn Hennessy, Chief Murphy and other prominent villagers. There's some doin's expected come this day week.

⁂

We are hiding a coal supply away from our friends the enemy in chambers built in the bottom of the Panama Canal. Nobody's going to make an unexpected call on your Uncle Sam and find his fires out.

⁂

Relatives and friends, and others, have unveiled a statue to the Pilgrim Fathers in Southampton, England. While most of us never get any nearer a Plymouth Rock than the henyard, it's consoling to know that those jolly old roosters are still remembered in old Albion.

⁂

Some corn was raised in Illinois this year that was 17 ft. 2 in. high and produced 40 ears to the stalk. Hope this fact will bring down the price of Peoria "lubricant."

⁂

A frequent application of the garden hose keeps the English public statues real clean and perked up. Good plan to try hereabouts. Shakespeare's chin whiskers, Pete Stuyvesant's peg leg, George Washington's horse, Horace Greeley's lambrequins and a host of statuesque figures would be almost recognizable at times if old Dad Knickerbocker would buy a hose.

⁂

Doctor Diesel's death will be felt here as well as abroad, opines the "Engineering Record." "Imbued with the ambition of discovering a prime mover of high thermal efficiency, he always kept his attention steadfastly directed toward this great idea. He had a single great idea—and he clung to it."

⁂

Seven thousand men are at work building New York City's subway lines. The cost will be about $200,000,000. Soon there'll be 6,000,000 of us in Greater New York, and if we can't plow our way across the city, we must burrow under it

⁂

In a physicist's laboratory was discovered a spark phenomenon which in time grew to a worldwide usefulness—the wireless means of communication. As an instance, the other day it saved the lives of over 500 people on board the ill-fated "Volturno." Its usefulness is only beginning; no one knows its future power for good.

⁂

Ever seen a scarecrow—we mean a cornfield scarecrow? The Department of Agriculture has put the kibosh on the scarecrow by saying that the crow is a blessing, not a pest. And proved it on opening a crow's tummy and finding it full of detrimental bugs and insects—detrimental to the crops, that is. Seems like all our old institutions are fast disappearing.

⁂

If you know an A-1 "garbager" set him hep to Chicago. Some of the technical papers now carry a regular department heading: "Chicago's Garbage-Disposal Situation." "That city had two years to provide for handling the garbage, and has fallen down," says a contemporary. Let's see, two-year-old garbage, and it fell down? Must mean knocked down.

⁂

Now that the airship becomes a greater menace in wartime than a tunnel across the English Channel, the tunnel is being seriously considered. Perhaps, some near day, J Bull and Jacques Bonhomme may be able to toddle over to see each other without their goloshes.

⁂

My word! but the "Electrical Times," London, for a technical journal is the giddy old thing. You'd jolly well believe it, old chap, if you'd read its account of the English National Gas Exhibition. It was ghastly! (Good joke, by Jove, eh what?) It blushed over the corset shop, it drooled over the "captivating young damsels," and it bloomin' near blew out the gas, because it doesn't like gas, y'know. I say 'Arriet, come 'ome with your 'Enry; this is no place for we.

A Practical Talk on Case-Hardening

By Frank Nicholson

NOPSIS—Case-hardening is usually a matter of guess ork. Suggestions for obtaining uniform results are rein given. The article will prove of value to engineers o usually have a goodly share of case-hardening to do.

Case-hardening is accomplished by taking advantage of e fact that iron and soft steel combine with carbon at nperatures above a low red heat.

Case-Hardening Operations

The essentials in case-hardening operations are as fol-ws: A suitable steel; the necessary furnaces and equip-nt; the carbonizing material; proper temperature.

The steel should be of good quality and uniform com-sition. A steel having the following analysis and me-anical properties is recommended:

Carbon not over 0.2 per cent. Manganese not over 0.5 r cent.
Sulphur not over 0.04 per cent. Maximum stress, 62,000 72,000 lb. per sq.in.
Phosphorus not over 0.04 per cent. Elongation in 2 in., per cent.
Silicon not over 0.05 per cent. Reduction of area 55 to 60 r cent.

This steel will be found to give the necessary me-anical properties when properly treated. It should be e from all mechanical defects, such as seams, rolling s, rolled-in scale, etc., and should preferably be an-aled before machining. This treatment will release all olecular stress set up in the rolling operation.

The furnaces may be heated by coal, coke or gas. It is sential that the furnace should be capable of maintain-g a uniform temperature. It is necessary that the rnaces should be equipped with pyrometers, so that the mperature can be regulated with precision and con-dence.

Thermo-electric pyrometers are the handiest for most ork, and they are easily manipulated. Care should be ken that the hot end of the thermocouple tube is placed such a position that it accurately indicates the tem-rature of the furnace. Near the furnace should be aced the quenching tanks, so that the work on reheating ay be quickly withdrawn and quenched. They should supplied with clear cold water, which should be fre-ently changed.

Carbonizing Material

As already pointed out, the carbonizing is effected by rbon and some of its compounds, while the metal is at red heat. Many mixtures have been used which will eld these necessary gases, including leather, charcoal, ne and bone charcoal, prussiate of potash, cyanide of tash and a mixture of charcoal and barium carbonate. he latter is recommended, the others being open to many jections. The proportions are 60 per cent. charcoal and per cent. barium carbonate.

Assume that we have a batch of work to be carbonized. he boxes to contain the articles should preferably be of rought iron, as this will stand much more fire than steel. or small work weighing only a few ounces to a few unds, boxes 12x8x8 in. will be quite large enough.

The packing should be carefully done. The bottom of the box should have a layer of carbonizing material about 1½ in. deep. The articles should be laid on this in such a manner that there is at least a space of 1 in. between each, and between them and the sides of the box. Another layer of material should then be laid on and the packing continued until the top layer is 1 in. from the top of the box. The material must not be rammed tight around the work, as carbonizing is chiefly effected by gases; sufficient space must, therefore, be left for free circulation.

If the materials and work are simply laid in and the boxes given several sharp blows with the hammer, the packing will evenly adjust itself. A test bar as nearly like the job as possible should be included in each box. The lid should now be dropped into position, so that it easily fits inside the top of the box. It should be luted on with wet clay, so that the gases generated may be retained to do their work and to prevent oxidation of the articles by the oxidizing gases in the furnace.

Carbonizing

With the furnace raised to a full red heat, the boxes are ready for charging. They should be put into the furnace in such a way that there is ample space between the sides of the furnace and the boxes and also between the boxes themselves. This will insure uniform heating and consequently better work. The boxes should be at a full red heat in from 1 to 2 hr., depending upon their number and size. The pyrometer should be inserted and the furnace regulated so that a temperature of 900 deg. C. is obtained. This should be maintained and not be allowed to exceed 925 deg. C.

In carbonizing, we are aiming to produce a case containing 0.8 to 0.85 per cent. carbon. This percentage will give us the necessary hardness without brittleness. If the temperature is raised too high the case will contain too great a carbon percentage, the articles will be likely to chip and flake; while if the temperature is not sufficiently high the article will not be hard enough.

An exposure of 3 hr. at a temperature of 900 deg. C. will yield a case of about $\frac{1}{32}$ in., and an exposure of 4 to 4½ hr. about $\frac{1}{16}$ in., which is ample for most purposes. When the operation of carbonizing is complete, the boxes should be withdrawn and allowed to cool slowly in the air. On no account must they be hardened in the good old hit-or-miss style by pitching into water.

If the test bar is now fractured it will be found to possess a coarse, granular fracture, which is said to "stare." The metal is in a very soft, weak and brittle condition and totally unfit for the purpose for which it is intended. This condition is caused by its exposure for a prolonged period at a high temperature. We see two distinct metals in the fracture, the case being much smaller in grain than the core. It is our business now to restore both the core and case to their greatest strength by suitably treating them.

Heat Treatment

Steel can be hardened by quenching from just above a certain critical point, which varies according to the

*Excerpts from an article in the "American Machinist."

percentage of carbon contained in the steel. If a sample of steel is quenched from a temperature inferior to its critical point, the change which should take place at that point does not occur and the metal is not fully refined or hardened. If it is reheated to a temperature superior to this point and is then quickly cooled, it assumes the finest structure that it is capable of assuming, and, with that, its greatest strength.

The temperature at which this change is effected in the core is about 875 deg. C. The case-hardened articles should be reheated to this temperature and the heat should be fairly quick. A prolonged soaking will result in the growth of the crystals, and if this occurs the metal will be brittle. When the heat has been reached and the articles are properly soaked through, they should be quickly withdrawn and immediately quenched in cold, clean water.

This treatment, although it has made the soft core strong and tough, has rendered the case very brittle, because its refining temperature has been much exceeded. The articles should now be reheated to a temperature of from 770 deg. to 790 deg. C., and quenched as before. This treatment will produce a case which is deadhard, but which will leave the core unaffected. The reason for this is that the second temperature has not been sufficiently high to undo the effects of the higher temperature.

A heavy case will fracture long before the core, but it forms a line of weakness which will result in the fracture of the whole.

Many jobs may be greatly improved by tempering. Where great strength and toughness are desirable, even at the expense of a little surface hardness, the articles should be immersed for 10 or 15 min. in a bath of oil or tallow, heated to a temperature from 200 to 300 deg. C., according to the degree of temper desired.

A Combined Open Feed-Water Heater and Hot-Water Meter

It is hard for one to know how much better he might do if he does not know how well he is doing. It is hard to tell how much better one coal or one method of using it is than another if one has no way of measuring results.

There is nothing that can be put into a steam plant which will give the operator more valuable information, more inspiration to effect improvements and more guidance in carrying them out than a meter on the boiler feed-water supply. The advantages of combining such a meter with its open heater was impressed upon the Harrison Safety Boiler Works, Philadelphia, and it has furnished a considerable number of its heaters so equipped.

The type of meter employed is the V-notch weir, in which the cross-section of the orifice occupied by the flowing water is always a triangle of the same shape having, therefore, a constant ratio of depth to width. At small flows the variations in head are rapid, giving a good percentage of accuracy. The formula connecting the head or depth in the weir with the quantity flowing was shown by Prof. James Thomson, of Glasgow University, in 1860 to be

$$F = 0.305\ H^{\frac{5}{2}}$$

where

F = Flow in cubic feet per minute;

H = Head in inches over apex of a 90-deg. notch.

A simple mechanism can be made to move the pen of a recorder in this relation to the depth of water in the weir as measured by a float, so that equal divisions upon the chart are passed over for equal increments of flow.

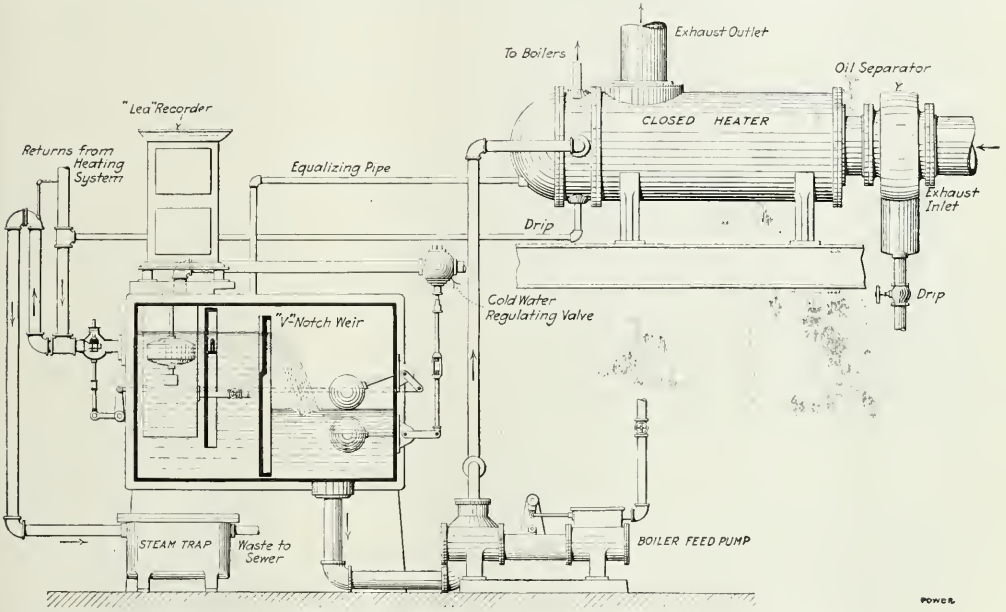


Fig. 1. Cochrane Feed-Water Meter Arranged for Use with Closed Heater

Such a meter requires but a small head for its operation, offers no inclosed passages nor constricted areas to be clogged up and provides storage between the measuring device and the pump so that the indications of the former are not affected by the vibrations set up by the latter. The placing of the meter in the heater makes it possible to measure water at any temperature or pressure.

In the Cochrane metering heater, or combined open feed-water heater and meter, the usual settling chamber is used as the still-water or approach chamber for the weir. A float in the outflow chamber on the down-stream side of the weir controls the cold-water valve through which make-up water is admitted to the heater and the open space above the water in the weir chamber is connected to the steam space of the heater by an equalizing pipe, as shown in Fig. 1. Where head room is limited

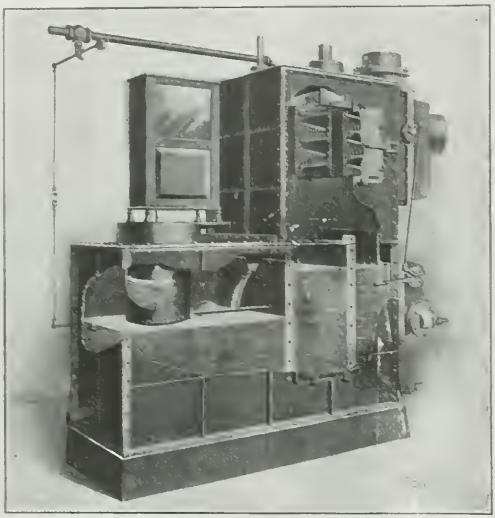


FIG. 2. BROKEN VIEW OF THE COCHRANE METERING HEATER

or large water-storage capacity is required a cylindrical form of heater is recommended. Where only part of the water is to be metered two-compartment heaters are supplied or a heater may be arranged to meter two supplies of water used separately. The metering apparatus can be attached to heaters already in use. Its connection to a closed heater is shown in Fig. 1, and to an open heater in Fig. 2.

The registering and recording mechanism is operated by a large copper float located in a chamber connected through a throttle or choke valve to the still-water chamber, and inclosed within the heater construction. From the float a brass rod rises vertically through a stuffing-box or anti-vapor gland into the recorder casing, where it carries a vertical rack engaging with a pinion mounted on the spindle of a spiral cam. This cam is so laid out that a pen carriage is caused to travel equal distances horizontally for equal increments in the rate of flow. The pen in turn bears upon a drum which is revolved once in 24 hr. by an eight-day clock. The chart upon which the record is made is wrapped around this drum, and, inasmuch as distances crosswise represent flow in pounds per hour, and distances lengthwise represent hours, the area of the chart under the pen tracing represents, to an appropriate scale, the total flow in pounds of water during any given period.

The area under the curve may be determined either by means of an ordinary planimeter, or an automatic integrating device can be provided which gives directly the total flow corresponding to any elapsed period. In any case the record made by the pen is of value independently of the integrated result, since it shows the variation from moment to moment throughout the day.

The vertical rack rod of the recorder is fitted with a pointer traveling over a scale divided into inches, which serves the double purpose of affording an easy means of initial adjustment of the instrument, and of computing the flow directly, independently of the cam. The surface of the cam is also marked so that the flow may be read off independently of the pen, furnishing a means for adjusting or checking the adjustment of the pen upon the chart at any time.

Two Cochrane metering heaters of very large capacity have recently been supplied for the new Two Hundred and First St. power plant of the New York Edison Co. The discharge of the condenser air pumps is first received in the metering hotwell located on the turbine-room floor, from which it divides and passes in equal parts to the two metering heaters on the floor below. This hotwell also receives and divides, but does not meter, the make-up water. It has a total capacity of 1,200,000 lb. of water per hour. The metering heaters are installed according to the double-unit system, that is, in parallel, both as regards the exhaust-steam supply and the withdrawal of water, each having capacity of 600,000 lb.

The meters are guaranteed to give a result when integrated over an hour, day or week, that will agree with the amount of water as determined by weighing, within 1½ per cent., variation in temperature of the water not to exceed 25 deg. F. above or below the temperature for which the instrument is designed.

In a test recently made at the works of the manufacturer upon a meter designed to deliver 300,000 lb. of water per hour an average error of only 0.48 per cent. was obtained.

Thyssen Vacuum Pump

There has recently been put on the market an interesting centrifugal air pump for high-vacuum service. This pump is patented, is the design of Thyssen & Co., Mulheim-Ruhr, Germany, and has been in operation in many of the largest power stations of Europe for several years.

The development of the Thyssen air pump, herein described, was due to the necessity of having an efficient high-vacuum pump for large turbine units, that would take up little space and be free from the objections of reciprocating air pumps and at the same time eliminate the shortcomings of some of the centrifugal air pumps already on the market.

A section of the pump is shown in Fig. 1, from which will be seen that the machine is practically a double-impeller, single-stage centrifugal pump with horizontally divided case. Each impeller discharges into an annular nozzle from which the water emerges in a thin film of high velocity, entraining the air from the condenser

through an annular diffuser or conversion throat and discharging the mixture against atmospheric pressure.

The moving element consists of two single-stage impellers mounted right and left hand on a driving shaft and between them is mounted a disk carrying two nozzle rings. There are four of these nozzle rings, the other two being separate and stationary, one attached to the casing and the other forming a sliding sleeve which is controlled by a hand-operated external adjustment that can be moved axially, thus varying the width of opening between the rotating and stationary rings to regulate the quantity of water for a given speed and temperature of entraining water.

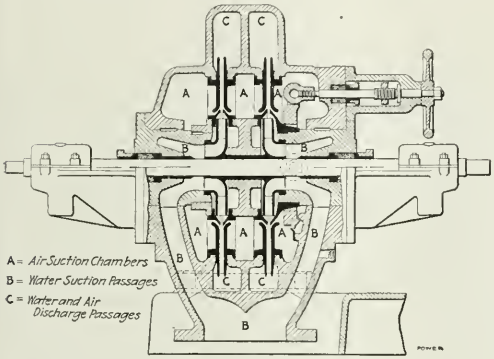


FIG. 1. CROSS-SECTION OF THYSSEN PUMP

The action of the pump is as follows: The entraining or "hurling" water is drawn into the pump, as in an ordinary centrifugal pump, and discharged by the impellers in two parallel films. Each discharge nozzle consists of a stationary and a revolving ring, by which the particles of water are given a swirling movement which greatly increases the air-entraining effect of the water leaving the nozzle rings. In order to permit the impellers to retain their central position under the nozzle rings with varying positions of the adjustable ring, a small lateral movement of the nozzle ring is immediately followed by a movement of the shaft endwise, bringing the pump instantly into hydraulic balance by discharging the water pumped by the two impellers through the annular openings of equal width between the two sets of nozzle rings. The pump is commonly located over a small tank, as shown in Fig. 3, but can be arranged to draw and discharge the entraining water in parallel with the circulating pump if preferred.

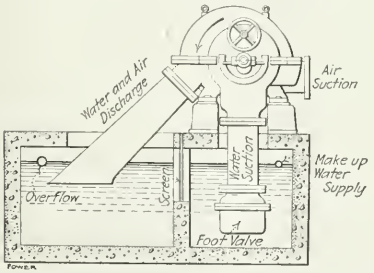


FIG. 3. THYSSEN PUMP AND CIRCULATING TANK

These pumps are built for a wide range of capacities; speeds from 1000 to 3000 r.p.m. being permissible, permitting either economical turbine drive or slower speeds to suit motors.

Many attractive pump combinations for surface, jet and barometric condensers are possible with this machine, as in Fig. 2, where the circulating, Thyssen air and centrifugal hotwell pumps for a surface condenser, taking care of a 3500-kw. steam turbine, are shown; the compactness and simplicity of the design being obvious.

The C. H. Wheeler Manufacturing Co., Philadelphia, Penn., has acquired the sole manufacturing and selling

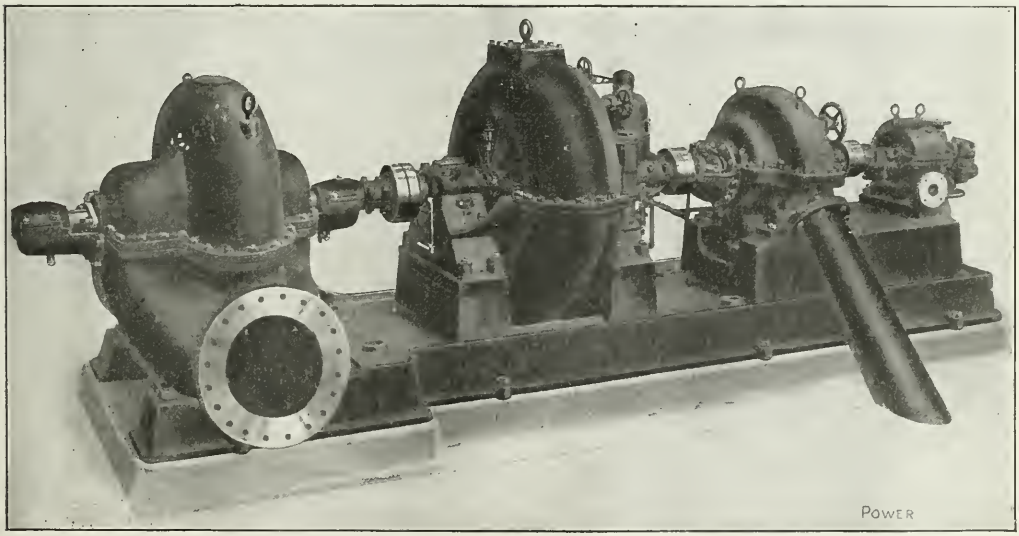


FIG. 2. TURBINE-DRIVEN AIR-CIRCULATING AND HOT-WELL PUMPS

gnts for the Thyssen pump in the United States and anada; and has already contracted to furnish a large umber of them for various power plants. They are uilt in sizes up to 15,000 kw. capacity in one unit.

❖

The Abatement of Locomotive Smoke*

By D. F. Crawford†

Locomotive Combustion Rates

Dense smoke represents some wasted fuel and as the st of fuel represents from 8 to 10 per cent. of the total perating cost of the railway, one of the most obvious ays of reducing operating expenses is to economize in e use of fuel.

To obtain from modern locomotives the average power quired from them it is necessary to consume fuel at e rate of about 100 lb. of coal per sq.ft. of grate per r., and to obtain the maximum power required it is necsary to consume 150 lb., and at times in excess of this mount, per square foot of grate per hour. That is, to btain the power necessary to perform the work deanded, a boiler which from its heating surface would rated at about 320 hp. is frequently forced to delop over 1500 boiler horsepower, and our records show at another boiler, which would on the basis of heating rface be rated at about 400 hp., has developed as high 1994 boiler horsepower.

The performance stated above requires coal consumpon at the rate of from 6000 to 10,000 lb. of coal per r., and in the cases cited this was done on a grate of 5 sq.ft.

From the above it is surely evident that the abatement the smoke from such combustion is beyond comparison ith the simplicity of taking care of the smoke from a ationary boiler with the low rates of combustion obined in such practice.

The Locomotive Stoker

For the past nine years the Pennsylvania Lines west Pittsburgh have been working to develop a mechanical oker for locomotive use, and the results so far have en sufficiently satisfactory to warrant its application a total of 300 locomotives, of which 215 are at work—3 in passenger, 130 in freight and 19 in switching serce.

Repeated comparisons of the smoke produced by locotives with and without the stoker show that those uipped with the stoker may be operated with from one-nth to one-third of the smoke made by similar locomoves in the same service without the stoker; the amount the reduction depending on the class of service and ntinuity of the run.

Two locomotives, one with and one without the stoker, ere attached to a double train of freight cars, so that ch locomotive was loaded to its capacity, and observaons of the smoke made while pulling the train up a avy grade. In this case the average smoke was as llows:

Stoker-fired locomotive	8 per cent.
Hand-fired locomotive	78 per cent.

The superheater, which is now applied to many locomotives, and which will be applied to many more in the future, does much toward the abatement of locomotive smoke, in that it permits operation at a given power output with from 10 to 20 per cent. less coal than a locomotive developing the same power not provided with a superheater. Less coal being required, there will consequently be less smoke.

Perhaps the most difficult problem in the abatement of smoke from locomotives, is the reduction of the amount of smoke made at the locomotive terminals, where fresh fires are made, to prepare the locomotives for service.

Notwithstanding careful instructions, supervision and experiments with different fuels, mixtures of fuels, and appliances, a satisfactory solution has not yet appeared.

Several years ago endeavors were made to collect the smoke and gases by suction fans and pass them through water sprays to precipitate the heavier contents, but without success, the size, first cost and operation cost prohibiting a plant of sufficient capacity. A modification of this arrangement, in which the smoke and gases are forced through a considerable body of water, is about to be put in operation.

At the present time the Pennsylvania Lines has under construction, at the engine house in Allegheny, apparatus to carry the smoke and gases from the locomotives in which fires are being prepared, through an underground duct and a fan, discharging them into a stack 150 ft. high, 7 ft. in diameter. It is felt that this arrangement will not only carry the smoke and gases considerably above the buildings immediately adjacent to the engine house, but, owing to the size of the stack, permit of considerable precipitation of the heavier particles.

The stack will be so located that it will be possible to interpose smoke-washing apparatus between it and the fan, should a sufficiently promising method be developed.

Elimination of the Steam Locomotive

In the present state of the art, of course, this means the substitution of electric motive power for all the locomotives now in use, as no other method is now available.*

The performance of the locomotive boiler compares favorably with the average results obtained in stationary practice, and the performance of the complete locomotive of modern construction, is sufficiently efficient to permit obtaining a coal rate of 2.1 lb. per i.hp.-hr., or 2.5 lb. of coal per hp.-hr. delivered at the drawbar of the tender.

The cost of everything electric is enormous. The cost of the electric locomotive is at least double that of the steam locomotive, which it is supposed to replace, and before electric locomotives can be operated it is necessary to incur a large additional outlay for power houses, transmission systems, track preparation and all of the other apparatus and material which is necessary to complete an electric system.

One estimate brought to the attention of the writer, provides an investment of about $200,000 for each steam locomotive displaced, or about ten times the cost of each of the latter.

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*Excerpts from a paper read before the 1913 convention of e International Society for the Prevention of Smoke.

†General superintendent, motive power, Pennsylvania Lines est of Pittsburgh.

*Except internal combustion. See "Power," Sept. 30, 1913, page 470, for description of the first Diesel locomotive.—Editor.

Staten Island Boiler Explosion

SYNOPSIS—Some light on the causes of the explosion at the plant of the Richmond Light & Railway Co., in which seven were killed and three badly injured.

In last week's issue brief mention was made of the disastrous boiler explosion which occurred at the plant of the Richmond Light & Railway Co., at Livingston, Staten Island, on Oct. 21; further details are herewith given.

As stated, six men were killed outright and four seriously injured; one of these has since died, making the total fatalities seven.

FIG. 1. VIEW FROM OUTSIDE OF BUILDING, SHOWING WINDOW BLOWN OUT

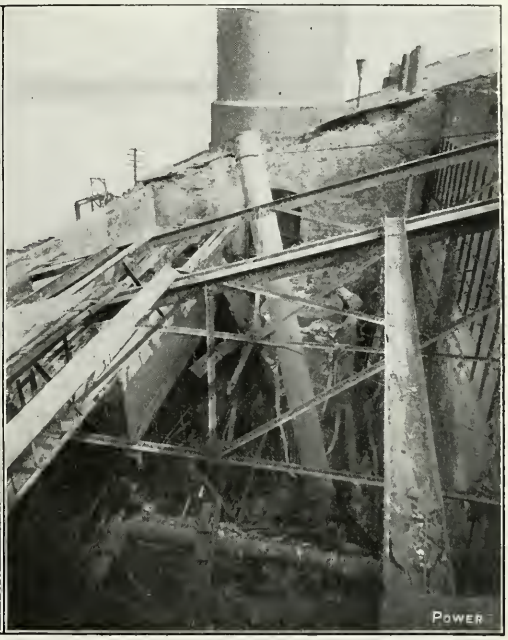


FIG. 2. LOOKING DOWN INTO BOILER ROOM THROUGH HOLE IN ROOF

The boiler was of the vertical Wickes type, rated at 300 hp. and had drums about 7 ft. in diameter. The pressure carried was 150 lb.; not 180 lb. as first reported. It had been installed in 1901 and the last internal inspection was made on Oct. 30, 1912.

As far as can be learned, the boiler had been washed out the day of the accident, and was put back in service to help carry the peak load. It had been cut in on the line only about 10 min. when the explosion took place.

The failure occurred in the bottom head, sending the boiler up through the roof like a rocket, the slight inclination causing it to descend in the Kill. The reaction drove the head with the mud drum attached, into the basement, these being found in the position shown in the sketch, Fig. 5. The mud drum was severed from the head, undoubtedly by striking a floor beam; this also caused the nozzle to be partly torn off through the rivets and the drum to be badly dented.

It will be remembered that the bottom head in this type of boiler is bumped to a radius equal to the diameter of the shell, but where the head is flanged up to join the drum it is necessary to depart from this radius. It was at this section (see Fig. 6) that the failure occurred in almost a perfect circle. Although there was some pitting of the lower head, it was not enough to cause apprehension and the metal at the line of the failure showed no signs of wasting away, in fact, it was little less than the original thickness of $\frac{3}{4}$ in.

In trying to account for the failure under these conditions it seems reasonable that with the "breathing" of the bottom head, the distortion would be greatest at the region of sharpest curvature, the very line along which failure occurred. This bending would tend to "fatigue" the metal and in this condition any sudden jar or impact might be sufficient to cause the rupture. It is not at all improbable that this initial force may have been caused by cutting in too quickly or by water-hammer. These are merely conjectures, however, and the coroner's inquest, which has not yet been held, may throw further light on what actually occurred when the boiler was cut in.

Previous to the explosion trouble had been experienced through failure of the braces which join the lower tube sheet with the bottom head; one of these showed evidence of having been welded. Although these braces are intended primarily to support the tube sheet it is possible that they may have indirectly affected the strength of the head.

The boiler is said to have received hard usage without

FIG. 3. DÉBRIS IN BOILER ROOM

proper attention, and about three years ago Wickes Bros., noting the conditions under which the boilers were being operated, and being apprehensive of the results, offered to buy back the three vertical boilers but were unsuccessful. Furthermore, owing to the general condition of the boiler plant and the attitude of the management, the consensus of opinion among insurance companies for some time prior to the accident was that it was a bad risk.

There has been considerable talk of raising the boiler

FIG. 4. SHOWING HOLE IN ROOF

from the Kill to permit further examination. It is improbable, however, that this would reveal much more than is already shown by the bottom head, as far as the actual failure is concerned, although it would show the general condition of the boiler and for this reason it is desirable.

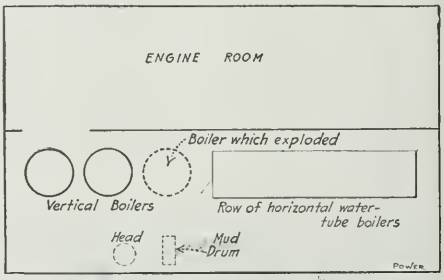


FIG. 5. PLAN OF BOILER ROOM AND POSITION OF HEAD AND MUD DRUM AFTER EXPLOSION

Staten Island was in total darkness for five nights as a result of the accident, although the engine room and the row of horizontal boilers were uninjured. The boiler which failed was situated between the stack and the other

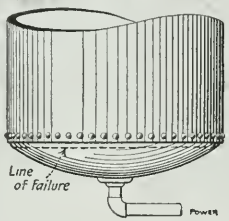


FIG. 6 SHOWING WHERE HEAD FAILED.

boilers; as a result a large section of the flue was demolished, and had to be replaced before service could be resumed.

Steam Turbines in a Modern Isolated Plant

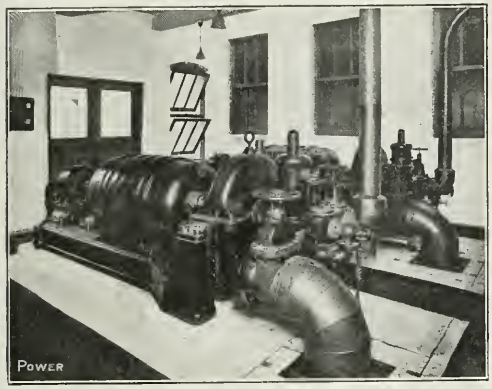
In electric-generating plants, the utilization of the exhaust from steam turbines for heating and in manufacturing processes often results in remarkable economy. The steam turbine is naturally the best suited to this condition, because of the steady supply of exhaust steam at a constant pressure and free from oil. Where this steam can be utilized, condensing operation is seldom justified.

The plant of the R. B. Davis Baking Powder Co., which is described herein, is a splendid example of this type of plant. The plant previously used live steam for drying and acid evaporation and purchased central-station current. They estimate a saving of 33⅓ per cent. over the old operating cost with their present equipment, including interest and depreciation, and it can readily be seen why the owners take pride and satisfaction in this plant.

The turbine room contains two Westinghouse alternating-current, turbo-generator units, of 150 kw. normal capacity each, having direct-connected exciters mounted up-

on the turbine bedplate. These machines generate current at 450 volts for lighting and power service about the works.

The turbines exhaust at practically atmospheric pressure and the supply of exhaust steam is used for heating and drying in the manufacture of baking powder. As the plant operates continuously night and day, there is a



TWO 150-KW. WESTINGHOUSE TURBINES WITH DIRECT-CONNECTED EXCITERS

continuous and practically constant demand for this exhaust steam. Live steam can be turned into the heating system in case of emergency. By means of an air pump the steam is withdrawn from the heating system under vacuum, and is fed back to the boilers through a Goubert water heater, a makeup supply of feed water being added. A feed temperature of approximately 200 deg. F. is obtained, the exhaust steam passing through the heaters on its way to the heating system.

In the turbine room there is a four-panel switchboard, peculiar in that the conductors are bare copper bars extending straight up from the switches and through a slate shelf above which they join the distribution leads. There are three transformers of 5 kw., each arranged in delta, the secondary not being connected in this case, as two of the plant buildings are supplied with three-wire, 220-110-volt current, and one building with two-wire, 110-volt current.

There is also a 15-hp. motor-generator set installed to carry the variable-speed, direct-current elevator load, consisting of two automatic A. B. C. elevators.

In the boiler room there are two 250-hp. Babcock & Wilcox boilers, the extra capacity being needed for furnishing live steam for evaporating acids in the baking-powder process. These boilers generate steam at 150 lb. pressure, using a good grade of Clearfield smokeless bituminous coal. With an electrical load factor of about 53½ per cent., including the steam used for acid evaporation, which is hard to estimate, the plant uses approximately 7½ tons of coal per day of 24 hr. There are installed about the plant about 225 hp. in motors of the squirrel-cage, induction-type, chosen for their advantages over the commutator type which are susceptible to trouble from dust.

Throughout the whole installation the most efficient use has been made of the power and the plant is a good example of sound engineering and commercial judgment.

Huber Shaking and Dumping Grate

The illustrations shown herewith give an idea of the general design of the Huber shaking and dumping grate. The bars are made with two trusses running lengthwise with clips bridged across from truss to truss. These clips can be regulated for any size of opening desired. One truss is straight; the other is curved and deep, giving the bar extra strength to prevent warping, and a large opening when the bar is in a raised position.

Referring to Fig. 1, the grate-bar bearings are placed off the center line, which gives an eccentric movement toward the back of the furnace. This movement advances the coal to the rear of the furnace, sifts out the ashes and at the same time breaks up the fire. The grates are shown in their running position.

The stoking feature is shown in Fig. 2. Alternate grate bars are connected to a side bar, which is connected to a lever on the front of the furnace. On the other side of the grate is a similar side bar, connected to a second lever by which the remaining grates are operated. Pulling out on either lever brings the grates to the position shown which moves the fuel toward the rear of the furnace. When both levers are pulled the grates are in the position shown in Fig. 3. The bars can be raised from 1 to 5 in.

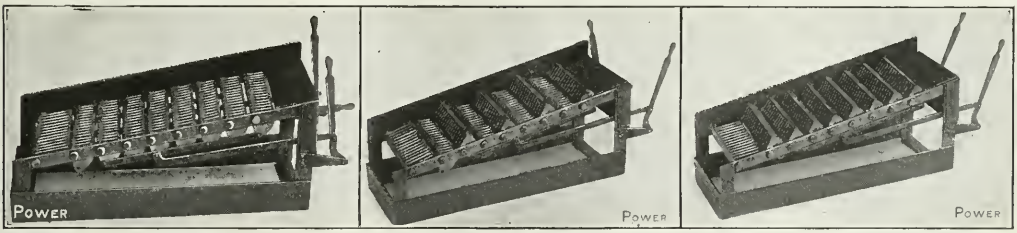


FIG. 1. FIG. 2. FIG. 3.

THE HUBER SHAKING AND DUMPING GRATE IN ITS VARIOUS POSITIONS

The grates are made with over 50 per cent. air space. The dumping grate is 12 in. wide. This grate is manufactured by the Huber Grate Bar & Stoking Co., 1114 East Monument St., Baltimore, Md.

Two locomobiles of 350 hp. each have been imported from Germany by the Buckhorn Mining Co., of Nevada. They are to use crude oil as fuel, and were sold upon the guarantee of 0.6 lb. per b.hp.-hour.

Y. M. C. A. in Industrial Work

Nearly 3000 college engineering graduates and 3500 students from 160 colleges, reports the national association, are at work in the industrial field of the United States teaching foreign men and boys how to read and write, learn trades and become useful citizens. These teachers are members of the association, under its supervision, and call their work "the industrial-service movement."

For English-speaking workmen the plan includes instruction in shops and factories at the noon hour or after closing time; classes in mathematics, mechanics, drawing, planreading, etc.

The work is helping the engineer and student to acquire an intimate knowledge of shop conditions and become broadsage executives, and is giving the workmen a better acquaintance with the college man, whom, as one employer expressed it, "we no longer think of as a snob."

⁂

Panama's Exposition

The corner stone of the administration building to be erected on the site of the national exposition, which Panama proposes to hold in 1914-15 in commemoration of the four hundredth anniversary of the discovery of the Pacific Ocean by Vasco Nuñez de Balboa, was laid on Thursday, Sept. 25, by President Porras.

The sites allotted for the different buildings were blessed by the Bishop of Panama, Dr. William Rojas, and the plans were exhibited by Alejandro Bermudez, the director of the exposition. Following the laying of the corner stone, Dr. Ramón F. Acevedo, secretary of public works, made an address. The day was made a public holiday in Panama, partly on account of the corner stone ceremonies, and partly because Sept. 25, under the old calendar, was the date in 1513 when Balboa first saw the Pacific.

It is planned to open the exposition on Nov. 1, 1914, to continue six months, and for carrying out the project the Panama National Assembly has voted a preliminary credit of $150,000. The United States, Spain, and several of the neighboring Latin-American republics have been invited to participate. The grounds front the road to Las Sabanas, about opposite the orphan asylum, and cover an area of about 35 acres.—"Canal Record."

⁂

International Engineering Congress

In connection with the Panama-Pacific International Exposition in San Francisco, in 1915, there will be an International Engineering Congress, in which engineers throughout the world will be invited to participate.

The congress is to be conducted under the auspices of these five national engineering societies, the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and the Society of Naval Architects and Marine Engineers.

The organization and conduct of the congress are controlled by a committee of management consisting of the presidents and secretaries of these five societies, and of eighteen other members in or near San Francisco.

Col. George W. Goethals, chairman and chief engineer of the Isthmian Canal Commission, has consented to act as honorary president and is expected to preside in person over its general sessions.

The congress will hold its sessions during the week of Sept. 20-25, 1915, in the auditorium and section rooms which will be placed at its disposal by the management of the Panama-Pacific International Exposition Co.

Two important purposes are: First: The gathering together of a large and representative body of engineers from all civilized countries, with the opportunities which this will present of forming or renewing personal acquaintances, and of interchanging views on the various phases of professional work. Second: The reading and discussion of papers before the sections, and their later publication in such form as to constitute a valuable addition to any engineering library.

In scope of character, it is intended that the congress shall embrace, in a thorough and comprehensive manner, the various branches of the engineering profession. Eminent engineers throughout the world will be invited to contribute papers on assigned topics, and in selection and distribution the committee will use its best endeavors to render the series of resulting papers widely representative of the world's best engineering practice.

The general field of engineering to be covered has been divided into 10 groups which, together with the special field of the Panama Canal, will constitute 11 divisions, each presided over by a chairman eminent in the branches of engineering covered by his section. Each section will hold independent sessions, with such joint and general sessions as may be suitable. The following is a general indication of the sections and the branches of engineering which each will cover:

General Sessions: Official and general addresses, discussions on topics of general professional interest, business meetings, etc.; Section 1, the Panama canal; 2, waterways and irrigation; 3, railways; 4, municipal engineering; 5, materials of engineering construction; 6, mechanical engineering; 7, electrical engineering; 8, mining engineering; 9, naval architecture and marine engineering; 10, military engineering; 11, miscellaneous.

The official language will be English, and all proceedings and transactions will be so published. The papers solicited will be welcome at the choice of the author; if in other than English, they will be translated, and, together with all papers presented in English, will be printed in this language for presentation.

A special effort will be made to procure discussions, carefully prepared in advance, for presentation with the papers. In addition, there will be oral discussions at the sessions. It is anticipated that limitations of space may require the ultimate publication of all discussions in condensed or summary form. Written discussions will be welcomed in any language; if in other than English it will be translated for publication. It is expected that oral discussions will be limited to English.

The general fee for membership will be $5. This will entitle the member to receive the index volume and any single volume of the transactions he may select, together with the right of participation in all general activities and privileges.

It is expected that there will be arranged a number of excursions to points of engineering and general interest within practicable reach of San Francisco, and every effort will be made to enable visiting engineers to inspect personally such engineering works as are especially typical of engineering practice on the Pacific Coast.

Further information of general interest and importance will be given publicly through the technical press, and to all subscribers timely notice will be sent containing more complete and detailed information as to papers, sessions excursions, itineraries, etc.

PERSONALS

A. O. Krieger, at one time publicity manager of the Busch-Sulzer Bros.-Diesel Engine Co., St. Louis, Mo., has been placed in charge of the gasoline-engine sales department of the Whitman Agricultural Co., St. Louis.

Dr. Ira N. Hollis, president of the Worcester Polytechnic Institute and a vice-president of the American Society of Mechanical Engineers, was honored on Oct. 17 by a meeting and banquet in Worcester by the Massachusetts members of that society.

Francis MacLehose was recently appointed superintendent of the Chattanooga & Tennessee River Power Co.'s hydroelectric station at Hale's Bar, Guild, Tenn. This station is 33 miles below Chattanooga. Mr. MacLehose was graduated from the Stevens Institute of Technology in 1906, with the degree of mechanical engineer, and was in the operating department of the New York Edison Co. for seven years following his graduation.

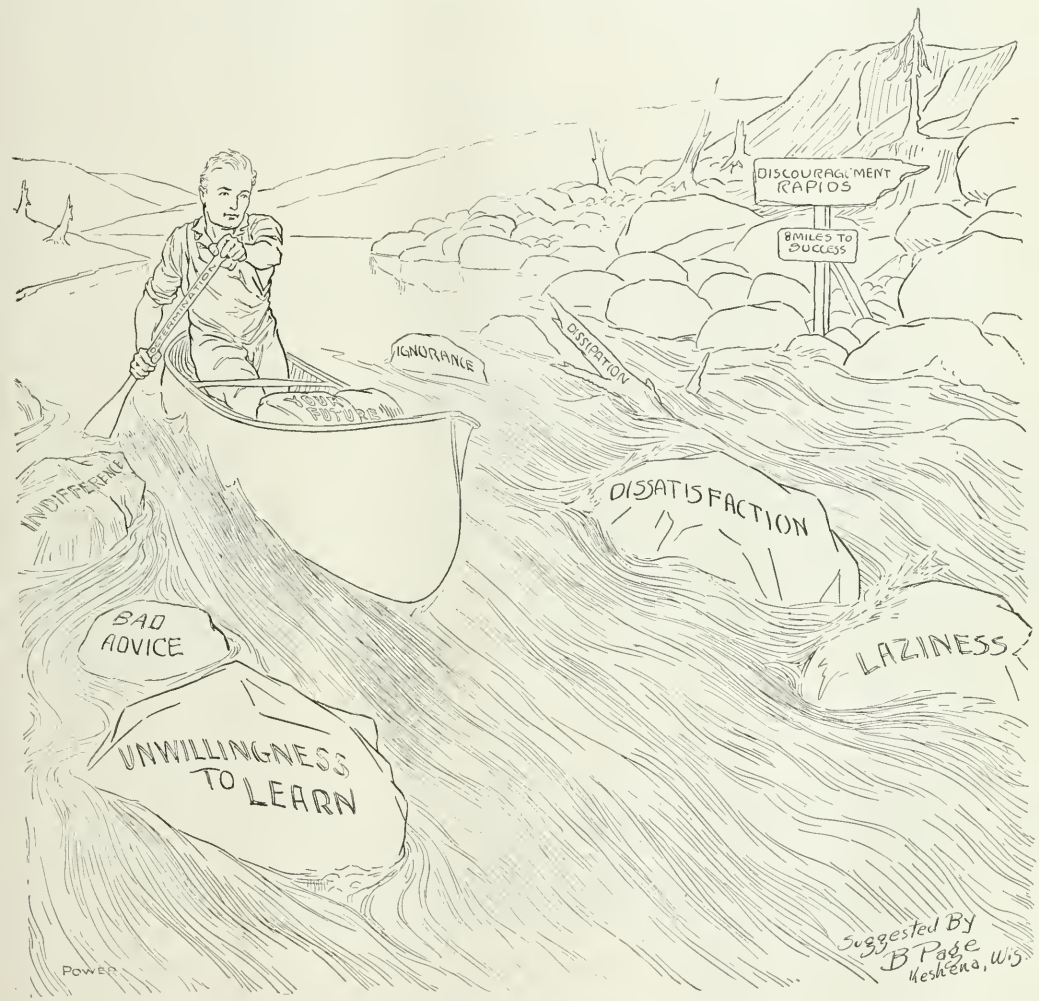
President C. O. Mailloux, of the American Institute of Electrical Engineers, who is soon expected home from a European trip, where he attended the meetings of the International Illumination Commission in Berlin last August, and the International Electrotechnical Commission in September, has been signally honored by the President of France, who has conferred upon him the decoration of Chevalier of the Legion of Honor.

⁂

Bulletin No. 17 on "The Manufacture and Use of Shelby Seamless Steel Tubing," which has recently been issued by the National Tube Co., of Pittsburgh, contains in its 39 pages some very interesting and valuable information on the above subjects. The bulletin is made up from extracts from an address by J. H. Nicholson and Emil Holinger to the U. S. Naval School of Marine Engineering. It discusses the processes of manufacture, materials for steel pipes, the making of specifications and the application of tubular sections to machine design. The information imparted is not generally found elsewhere so that the bulletin should be of general interest. A copy will be sent by the company upon request.

POWER

Vol. 38 NEW YORK, NOVEMBER 11, 1913 No. 20



AVOIDING THE ROCKS

Latest Addition to Fisk Street Station

NOPSIS—The present addition, consisting of one 000-kw. and one 20,000-kw. turbines, marks a de- ture in the company's practice from vertical to hori- tal units and brings the total service capacity of the ion up to 165,000 kw. A kinetic air ejector for the denser of the larger turbine is a feature expected to duce an exceptionally high vacuum. The steam-produc- equipment is arranged on the unit plan and coal- ash-handling facilities are unusually complete.

In our issue of Nov. 4 the 25,000-kw. English Parsons bine for the Commonwealth Edison Co., of Chicago, described. This unit is now being installed in the

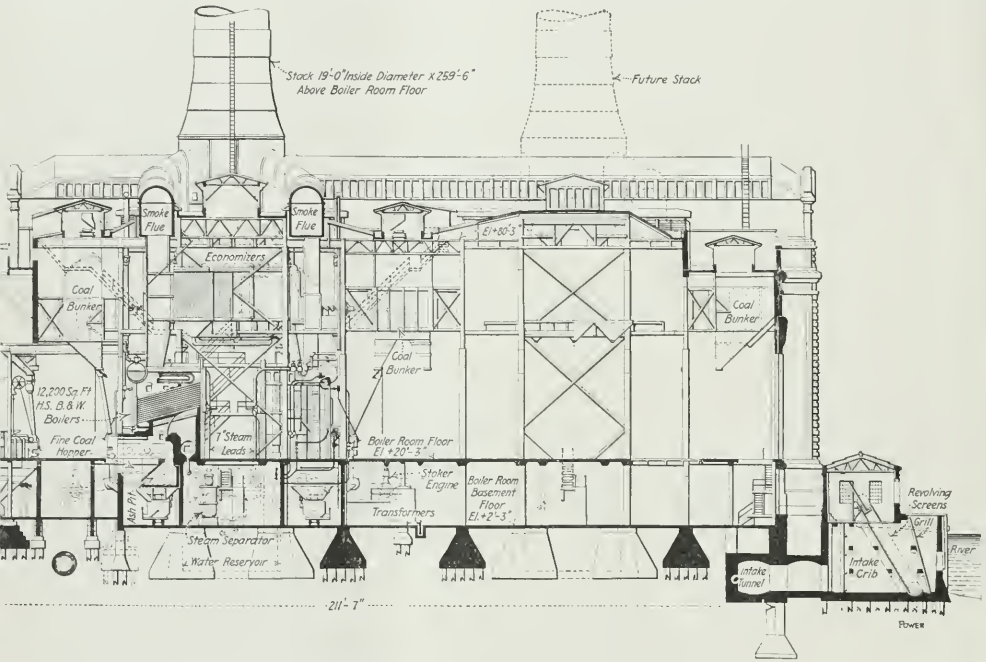


FIG. 1. TRANSVERSE SECTION THROUGH BOILER ROOM OF NEW EXTENSION TO FISK STREET STATION

extension to Fisk St. station. The extension is to contain a 20,000-kw. horizontal turbo-generator be supplied by the General Electric Co. The installa- of horizontal units is a departure from the usual ctice of the company, at least in this particular sta- . Since its inauguration in 1903 nothing in gen- ing units has been installed but vertical Curtis turbo- erators. At the present writing the existing station reached a service rating of 120,000 kw., and the ad- on of 45,000 kw. will give to Fisk St. a total capac- of 165,000 kw. The extension for the new equip- nt is now under construction and extends back for a ance of 170 ft. to the south branch of the Chicago er. It is about 25 ft. wider than the older portion of building, which measures 240 ft. The total length he building, including the extension, will be 675 ft.

BOILERS AND ACCESSORIES

As in the past, the unit system has been adopted. Individual groups of boilers supply the particular unit for which they are installed. An extension for this and other units is being added to the switch-house. All units and their accessories are so arranged that they can be operated practically independently. The general arrangement of the present addition to the plant is shown in the accompanying illustrations.

For the 25,000-kw. Parsons turbine the boiler equipment consists of four cross-drum type B. & W. water-tube boilers, which are of especially wide section, 42 tubes in width, with headers 14 tubes high. Each boiler contains 12,200 sq.ft. of heating surface and about 20 per cent. additional surface for superheating. They are equipped with chain-grate stokers and steel-encased settings. Each boiler is provided with two stokers separated by a firebrick wall which comes slightly above the surface of the grates. These stokers are 10 ft. 6 in. wide and 13 ft. long. The boilers are designed to evaporate 80,000 lb. of water per hour under continuous working conditions. The maximum working pressure is 225 lb. per sq.in., and the normal pressure 210 lb. gage. The superheaters will give 225 deg. F. superheat when operating at or near the maximum capacity.

As shown in the drawings, economizers have been provided, one for each boiler, containing 8500 sq.ft. of heating surface made up of 528 twelve-foot tubes, arranged in three groups of 16 sections each. The first group is

12 tubes wide; the second 11 tubes wide, and the third 10 tubes wide. As regards water circulation, the three groups are connected in series, and the circulation in each group is up the first eight sections, down the next four, and up the last four. Each economizer is equipped with an induced-draft fan having a capacity of 80,000 cu.ft. per min. and designed to maintain 1½-in. draft in the uptake of the boiler. Under ordinary operating conditions the economizers are designed to raise the temperature of the feed water about 150 deg. This equipment was furnished by the B. F. Sturtevant Co.

One smoke-stack has been provided for two units. In this particular case it will serve eight boilers. The stack is 19 ft. inside diameter and its height 250 ft. above the boiler-room floor.

Coal- and Ash-Handling Equipment

This feature of the plant is of particular interest, as every facility is provided to handle quickly and with the greatest economy the large quantity of coal required by boilers. There are three belt conveyors for the four groups of boilers. The bucket conveyors have a capacity of 175 tons of coal per hour each, at a speed of 45 ft. per min. The belt conveyors have a like capacity, at a speed of 250 ft. per min.

Per boiler, the capacity of the coal bunkers is 225 tons. In addition for serving four station units, there are four storage bunkers overhead in the train shed, with an aggregate capacity of 3360 tons, and receiving hoppers having a capacity of 1320 tons.

The removal of ashes will be accomplished by means of small electrically driven ash cars operating in the boiler-room basement. These cars discharge into a receiving hopper, which delivers to the bucket conveyor previously mentioned, and which may be used to elevate the ashes to a storage bunker above the track in the train shed, having a capacity of 1180 tons. From this point the ashes are discharged into standard railway cars for removal.

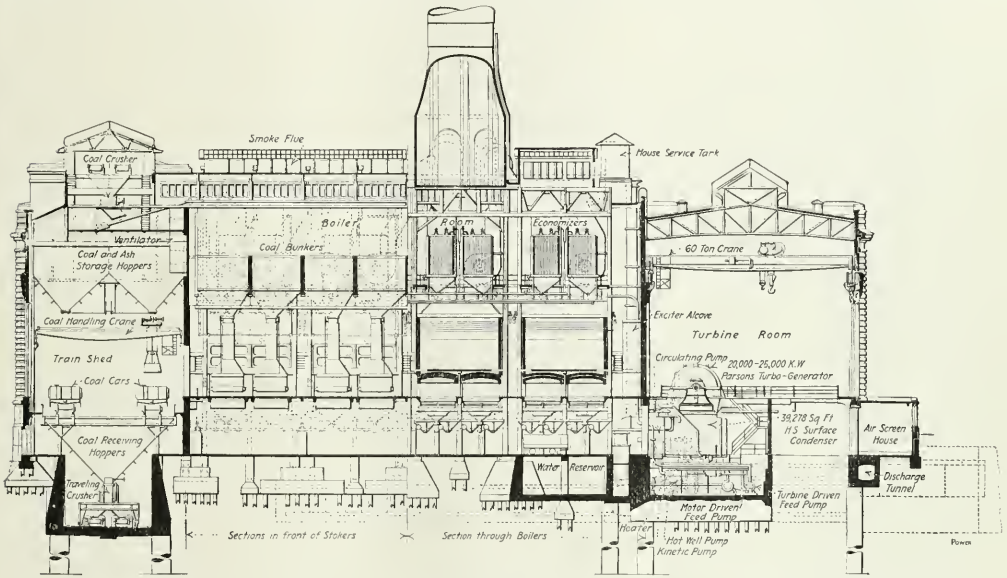


Fig. 2. Section through Boiler and Turbine Rooms of the New Addition to Fisk Street Station

the boilers. Coal cars are brought into the train shed on either unloading track, from which point the coal may be dumped directly into the hopper of the primary crusher, if the cars are of the drop-bottom variety; or if gondola cars, the coal may be unloaded by grab-bucket cranes and dropped over the side into the crusher hopper. The primary crusher is intended to reduce all lumps to about 3- or 4-in. cubes, and from it the coal is passed into the lower horizontal run of either of two Mead-Morrison overlapping bucket conveyors, which will care for the four groups of boilers. The bucket conveyors elevate the coal to a point above the boiler-room coal bunkers, and deliver it to the secondary crushers to be reduced to ¾ in. size. All of the crushers were furnished by Orton & Steinbrenner. From this point the coal is taken by a Robins belt conveyor running at right angles to the bucket conveyors, and is delivered to the bunkers over the

20,000-Kw. Unit

The General Electric horizontal turbo-alternator to be installed has a continuous full-load rating of 20,000 kw. at 80 per cent. power factor, or 25,000 kv.-a. Current will be generated at 12,000 volts, 60 cycles, and the unit will operate at a speed of 1200 r.p.m. The turbine is of the Curtis single-flow type, the first wheel having a double row of buckets, and the remaining wheels each having a single row of buckets. The shaft bearings are provided with forced lubrication from a pump geared to the main shaft. The bearings are water-jacketed, in addition to which the oil will be cooled, as it circulates, by means of coils immersed in the turbine-oil reservoir. The main turbine housing is anchored at the exhaust end to the sub-base and is supported on a sliding bearing at the throttle end, this arrangement being adopted to prevent expansion strains. The generator housing is bolted rigidly to

ub-base. Governing is accomplished by means of the m heretofore used on Curtis turbines. The gen- or is arranged for self-ventilation by means of vanes ne rotating field. Excitation is provided by means of rect-connected exciter operating at 250 volts.

ne entire condenser installation for this unit is being ished by Henry R. Worthington. The condenser is ed directly beneath the turbine-exhaust outlet and orted partly by the turbine housing and partly eams. It contains 35,000 sq.ft. of cooling surface, of O. D. No. 18 B.w.g. tubing, the tubes being about t. long. The condenser shell is of semi-circular -section, built of cast iron and heavily ribbed. The enser is arranged for two passes of the circulating r. The steam inlet is 8 ft. by 14 ft. 6 in., and the ection for circulating water 42 in. in diameter.

ne circulating outfit consists of a motor mounted on a plate between two independent centrifugal pumps, having its own suction and discharge connections. discharge pipes are interconnected at the inlet to the enser, and are provided with valves which permit ng out either pump. In addition, the pumps are ded with shaft couplings, so that either may be dis- ected from the motor. The combined capacity of the circulating pumps is 36,000 gal. per min., at 375 ., against a total dynamic pressure of 15 ft. One p alone will deliver 26,500 gal. at the reduced head quent upon the lessened velocity of the water through condenser and connections. With this arrangement apacity of both pumps will ordinarily be used dur- he warmer months, and in winter one pump alone deliver sufficient water.

ne arrangement of the hotwell pump is similar to of the circulating-pump unit just described. The vacuum pump is of the reciprocating angle type, as ufactured by the Laidlaw-Dunn-Gordon Co., with cal steam cylinder, and horizontal vacuum cylinder. steam and vacuum cylinders are double-acting, the n cylinder being 10 in. in diameter and the vacuum der 35 in., with a common stroke of 30 in. At the mum speed of the vacuum pump of 100 r.p.m., the acement is 3340 cu.ft. per min.

e installation of boilers and economizers is similar l respects to that of the 25,000-kw. Parsons unit. boiler feed two independent pumps are provided. e pumps are to be of the turbine-driven horizontal having three stages, and will discharge 375 gal. nin. when operating at approximately 3000 r.p.m. exhaust from the steam auxiliaries is all carried to ragwanath horizontal open-type exhaust feed-water r, which is constructed of ½-in. steel plate with the arrangement of trays. It will have a capacity of 00 lb. per hour and is guaranteed to heat the water 65 to 130 deg. F.

r the removal of the air and noncondensable vapors the condenser of the 25,000-kw. unit, a kinetic or has been provided. This piece of apparatus takes place of the so called dry-vacuum pump. It will be described on other pages of this issue.

is installation was designed by Messrs. Sargent & y, Chicago, consulting engineers for the Common- h Edison Co., and with them were associated Messrs. & McLellan, of Newcastle-on-Tyne and London, in ection with the design and construction of the Par- turbine unit and auxiliaries.

Cost of the Smoke Nuisance to Pittsburgh*

Before considering the loss to Pittsburgh, due to the smoke evil, it is interesting to note the estimated cost of the evil to other cities.

In 1899 the annual cost to London was estimated at $26,000,000. The committee on smoke prevention of the Cleveland Chamber of Commerce in 1909 fixed the loss to Cleveland at $6,000,000, or $12 per capita. Paul Bird declared that the annual loss to Chicago amounted to $17,600,000, or $8 per capita. The loss to Cincinnati has been placed at $8,000,000; this is allowing for a loss of $100 per family of five persons each, the 400,000 population being so divided that there were 80,000 families.

The total extra cost of dry cleaning in the city of Pittsburgh because of the atmospheric conditions is about $750,000.

According to the 1910 Census Report there are 86,942 dwellings in Pittsburgh. No doubt 50,000 of these houses are painted every three years. If it is said that the average cost of painting a house is $40 it then costs Pittsburghers $330,000 more a year for exterior painting than it does the people of other cities.

There are very few of the 104,000 buildings in Pittsburgh which do not have sheet metal either as a cover for the roof, or for gutters, spouts and flashings. If the average cost of renewing sheet-metal work on a building was placed at $100 and it was assumed that the work will last five years in Pittsburgh as against ten years elsewhere, then on 90,000 buildings it would cost Pittsburgh about $900,000 more a year under present conditions than if the city were practically free from smoke. Figuring an average cost of repainting sheet-metal work at $8 and assuming that repainting is necessary in Pittsburgh every three years as against five years elsewhere, it would be found that it would cost Pittsburgh about $108,000 a year more for repainting than it would cost other cities.

Wall papering is found necessary in Pittsburgh every two years, while in other cities it is found necessary only every six or ten years.

Pittsburgh pays $150,000 a year to keep the wall paper in its homes in even presentable condition, and it pays $400,000 more a year for wall papering than do cleaner cities.

On an average it costs Pittsburghers $12 to $14 a year to keep their curtains clean, while it costs the people of other cities $6 to $7.

The smoke in the atmosphere of Pittsburgh necessitates extra artificial lighting in the stores. The same is true of the homes of Pittsburgh. There are about 14,000 homes in the city which use electricity for artificial lighting purposes. The average cost to each home is about $24. If it is allowed that one-fourth of this amount is an expense due to atmospheric conditions which in turn can be traced to smoke, then it costs the 14,000 homes $84,000 a year for the extra lighting required.

The business section of Pittsburgh ranks second in the amount of soot-fall among the twelve stations in various

*Excerpts from a pamphlet by John J. O'Conner and published by the Mellen Institute of Industrial Research and School of Specific Industries.

parts of the city, so the soot-fall is greatest where it does the most damage.

The wholesale and retail stores of Pittsburgh, exclusive of the department stores and larger wholesale dry-goods stores, suffer an annual loss of $1,650,000.

The damage to merchandise in the department stores varies from $6000 to $25,000 for each store; the cost of cleaning from $10,000 to $24,728; and the cost of artifical lighting from $10,000 to $15,000. If the items for the department stores are figured on the same basis as for the wholesale and retail stores, it will be found that the extra cost to them for all items would be in the neighborhood of $175,000.

It costs about $200,000 a year to keep the larger office buildings of Pittsburgh clean. One building pays $320 more a month to clean windows than if that building were located in New York, Boston or Philadelphia.

The artificial lighting bills of the downtown office buildings run from $3000 to $20,000 each annually. The cost of the artificial lighting of all the larger office buildings is in the neighborhood of $125,000. Of this amount no less than $40,000 represents the cost of the artificial lighting necessitated by atmospheric conditions for which the smoke is responsible.

On the fifteen prominent hotels in the city of Pittsburgh it is safe to say that smoke imposes an extra expense of about $22,000 a year.

The extra cost of lighting, cleaning and replacing goods worn by frequent washing to the hospitals is on an average $3600 each, or $55,000 for all the larger ones.

Best Vacuum with a Cooling Tower

By Paul A. Bancel*

Engineers generally realize that they cannot obtain as high a vacuum with a cooling tower as with a natural supply of cold circulating water. But there is some confusion as to just how high a vacuum is profitable.

The purpose of this analysis is to determine at what vacuum a condensing equipment with the natural-draft type of tower, is the most efficient commercially. The basis of the calculation is 10,000 lb. of steam per hour, which corresponds approximately to a steam consumption of a 500-kw. high-pressure turbine, or a 250-kw. low-pressure turbine. Ten million of British thermal units must be absorbed by the circulating water and dissipated to the atmosphere by the cooling tower.

Fig. 1 gives the sizes of Wheeler-Balcke natural-draft cooling towers required to dissipate the heat at different vacuums and with different quantities of circulating water, with the atmosphere at 75 deg. F. and 70 per cent. humidity. The abscissas represent degrees cooling of water in the tower, as well as gallons per minute.

Attention is drawn to some of the inherent characteristics of natural-draft cooling towers as illustrated by the curves.

(a) For any vacuum, the size of a natural-draft cooling tower dissipating a constant amount of heat may be slightly decreased by increasing the quantity of circulating water pumped over it. This, however, increases the operating cost as well as the first cost of the pump and condenser.

(b) For any given quantity of circulating water, the vacuum may be increased by increasing the size of the tower, but only to a certain limit, beyond which the vacuum cannot be increased, even if the tower is made extremely large.

(c) A natural-draft cooling tower is a chimney, consequently, the higher the temperature of the water the better the draft, the greater the volume of air and the greater the heat dissipation per unit of area.

Attempts have been made to analyze cooling-tower performance by coefficients of heat transmitted per unit of cooling surface, but with unsatisfactory results because the efficiency of a unit of cooling surface depends upon its arrangement as influencing the resistance to the flow of air. With a given design of tower, the cooling is almost entirely dependent upon the amount of air going through it. Like a boiler chimney, the area of its base determines the flow per unit of draft pressure.

In Fig. 1 the amount of heat is constant, but the temperature at which the heat must be dissipated and the amount of water both vary. At the lower temperatures there must obviously be a greater volume of air. But the lower temperature means less draft pressure; hence it is doubly important that there be a greater area of flow. This fact serves to explain the shape and position of the curves.

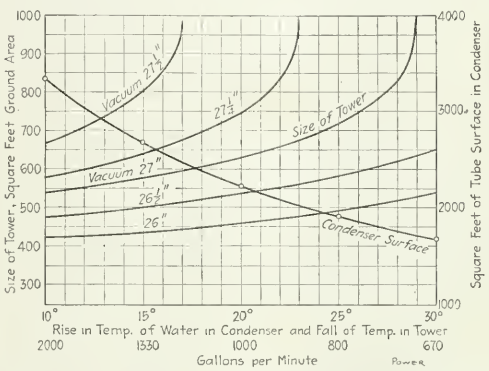


Fig. 1. Relation of Vacuum and Temperature Rise to Size of Tower

The chart also gives a curve of condenser surface corresponding to various quantities in gallons per minute and ranges of water temperature based on a difference of 5 deg. between outlet-water temperature and steam temperature. The curve is based on a heat transmission of 300 B.t.u. and serves for any vacuum, provided the outlet-temperature difference is 5 deg. F.

Let us turn to some actual figures. Suppose the steam consumption of a 500-kw. turbine is 20 lb. per kw.-hr. at 26 in. vacuum, and that the gain resulting from an in-

*Wheeler Condenser & Engineering Co., Carteret, N. J.

se of each inch in vacuum is 5 per cent., that is, the
n consumption at 26 in. is 20 lb., at 27 in. 19 lb., and
n. 18 lb.

et the yearly load factor be 50 per cent., so that the
ly turbine load is equivalent to 4380 hr. at full load.
ume that coal costs $3 per net ton and that 8 lb.
team is evaporated per pound of coal; then a pound
team per hour for a year is worth

$$4380 \times \tfrac{1}{8} \times \frac{3}{2000} \text{ or } \$0.82$$

f the turbine operates at 27 in. vacuum with a steam
umption of 19 lb. per kw.-hr., there will be a saving
00 × $0.82 or $410. Similarly, at 27½ in. vacuum
18½ lb. of steam per kw.-hr. the saving is 750 × $0.82
615 per year. The question now is, what is the most
nomical vacuum at which to operate.

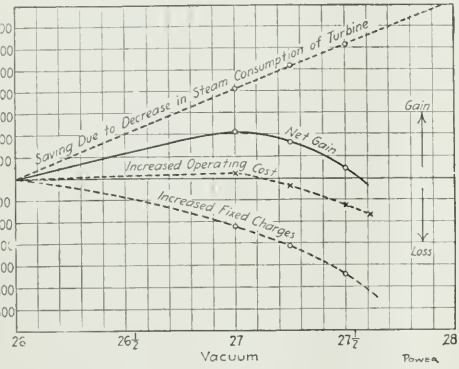


FIG. 2. RELATION OF VACUUM TO GAIN

rom Fig. 1, we may read the size of condenser, pump,
r, round area, etc., required for various conditions.
simplicity we will assume a total steam consumption
0,000 lb. per hr. for all vacuums.

able 1 shows the size, capacity and cost of the ap-
tus for four different degrees of vacuum.

TABLE 1

	Vacuum in Inches			
	26	27	27½	27½
perature rise, deg. F.	30	25	20	15
enser surface, sq.ft.	1635	1700	2230	2700
lating pump, gal. per min.	670	800	1000	1330
ne for circulating pump, hp.	20	25	30	35
nd area of cooling tower, sq.ft.	540	720	740	800
cost of condenser, pumps and tower	5625	6740	7350	8200

VING ON TURBINE VS. FIXED AND OPERATING COSTS OF CONDENSING EQUIPMENT

low the fixed charges on the foregoing investments,
the operating costs, must be balanced against the
ng in steam consumption of the turbine.

he fixed charges can be taken at 15 per cent., covering
rest, taxes, depreciation, etc.

able 2 summarizes the cost of the complete tower and
lenser outfit, at different vacuums, also the fixed
ges at 15 per cent. and the increase of fixed charges
the 26-in. equipment.

TABLE 2

acuum, In.	Cost of Condensing and Tower Equipment	Annual Fixed Charges at 15 Per Cent.	Increase over Cost for 26 In.
	$5265	$790	
27	6740	1010	$220
27½	7350	1100	310
27½	8200	1230	440

Considering next the operating charges of the condensing equipment, we find it necessary to make a correction for the saving due to feed-water heating by exhaust steam. While a large share of the heat is returned to the feed water, a certain percentage is consumed in work and friction; also, some of the heat is lost by radiation and leakage, and at times there may be insufficient feed water to condense all the steam in the feed-water heater. A fair assumption is that 75 per cent. of the heat is returned to the feed water, or that the steam consumption chargeable to the condensing apparatus is 25 per cent. of the gross.

The gross and net steam consumption of the condenser auxiliaries for the different vacuums above stated may be set down as follows:

TABLE 3

Vacuum, In.	Steam Consumption Air Pump, Lbs.	Circulating Pump per Hour	Chargeable to Condensing Plant, 25 Per Cent. Lb. per Hr.	Value of Steam Consumption per Year
26	600*	1200	450	$369
27	175	1500	420	345
27½	175	1800	500	410
27½	280	2100	600	492

*This comparatively high figure is explained by the fact that for the 26-in. vacuum a direct-acting reciprocating pump could be used, while at the higher vacuums a more efficient pump would be used.

The value of the steam consumed per year, as given in the last column, is based on 50 per cent. load factor, $3 per ton for coal, and the use of 8 lb. of steam per pound of coal.

With the foregoing data available we are now ready to determine at what vacuum the greatest net saving is obtained.

Table 4 is based on Tables 2 and 3 and gives the saving and losses in dollars at different vacuums as compared to 26-in. conditions.

In the last column the net saving is tabulated.

TABLE 4

Vacuum, In.	Saving by Decreased Steam Consumption of Main Turbine	Additional Fixed Charges	Additional Operating Cost	Net Yearly Saving over 26-In. Outfit
27	$410	$220	$24	$214
27½	513	310	41	162
27½	615	440	123	52

The above table shows that the most economical point lies near 27 in. This is shown graphically by the chart, Fig. 2, in which the heavy curve represents the net saving, the highest point indicating the vacuum required for the highest commercial efficiency. This curve also shows that if sufficient money were expended to obtain a vacuum as high as 27.6 in. there would be neither gain nor loss as compared with 26-in. operation.

The conclusions are all based on 50 per cent. load factor, $3 per ton for coal, 8 lb. steam per lb. of coal, a turbine saving 5 per cent. of its steam per inch increase in vacuum over 26 in., and having a steam consumption of 20 lb. at 26-in. vacuum, a Wheeler-Balcke tower and atmospheric conditions of 75 deg. F. and 70 per cent. humidity.

These conditions vary. The particular load factor at which the purchaser will operate his plant, the size of the plant, the type of turbine or engine, the cost of coal, the interest which he is obliged to pay on money, all affect the problem.

The chart, Fig. 1, can be used as a basis in most cases, multiplying by the ratio of actual steam to 10,000 lb., and the method outlined for obtaining chart No. 2, followed through for the exact conditions at hand.

Designing a 100-Hp. Horizontal Tubular Boiler

By T. G. Ranton

SYNOPSIS—Instruction is herein given how to determine the proper size of boiler to develop 100 hp., taking into account the grate area, heating surface and number of tubes, also the thickness of the shell plate and tube heads, number and size of braces, etc.

It is well known that the term horsepower belongs to the engine and not to the boiler. A boiler should be estimated from its evaporative capacity, that is to say; with so much coal per hour a boiler will evaporate so much water per hour at a given temperature into steam at a given pressure.

The standard horsepower is the evaporation of 30 lb. of water per hour into steam at 70 lb. pressure with a feed-water temperature at 100 deg. F. Therefore, a boiler necessary to develop 100 hp. must evaporate 3000 lb. of water per hour. One pound of coal, with average firing, will evaporate from 7½ to 8 lb. of water per hr., but to be safe we will assume that 1 lb. of coal will evaporate 7½ lb. of water per hr.

Grate Surface

Therefore, if the 3000 lb. of water evaporated per hour is divided by 7½, it will show that 400 lb. of coal per hour will be used to evaporate the water necessary to develop 100 boiler horsepower. With a good draft, proper combustion and clean tubes it will require 1 sq.ft. of grate surface to consume 12½ lb. of coal per hour. To find the necessary grate surface, divide 400 lb. of coal consumed each hour by 12½, which calls for 32 sq.ft. of grate surface to consume the necessary fuel.

A mistake is often made by not having space enough between the grate and the bottom of the shell. In designing a furnace for a 100-hp. boiler, the grates should be placed at least 32 in. from the bottom of the shell. Particular attention should be paid to the bridge-wall area. The bridge-wall should be built straight across the furnace and the area between the top of the bridge-wall and the bottom of the shell should equal at least one-fifth of the grate area. A sloping combustion chamber is preferred to a straight one.

Heating Surface

The heating surface of a boiler should be about 40 times greater than the grate surface; in other words, 1 sq.ft. of grate surface is sufficient for 40 sq.ft. of heating surface. Therefore, multiplying 32 sq.ft. of grate surface by 40, will call for a boiler having a total heating surface of 1280 sq.ft. to develop 100 hp.

Tests have shown that an inside tube area equal to one-eighth of the grate surface is sufficient to carry the gases of combustion to the chimney. Multiplying the 32 sq.ft. of grate area by 144 will give 4608 sq.in.; dividing this result by 8 will give 576 sq.in., which is the area required through the tubes. The tubes most commonly used are 3-in. outside diameter and are nearly ⅛ in. thick. Assuming the inside area to be 6 sq.in., divide 576 by 6, which will give 96 tubes 3 in. in diameter.

These tubes will go in a 66-in. boiler and allow sufficient steam space, good spacing of tubes and a 2½-in. vertical space in the center and no tube closer than 3 in. to the shell. This spacing would also allow a manhole below the tubes.

In order to find the length of the tubes and boiler it is necessary to find the heating surface of all the tubes for 1 ft. in length, also two-thirds the circumference of the shell for 1 ft. in length.

A 3-in. tube, 1 ft. long, has approximately 0.75 sq.ft. of heating surface. Then 0.75 multiplied by 96 equals 72 sq.ft. of heating surface in all the tubes for 1 ft. in length. Two-thirds of the circumference of the shell for 1 ft. in length is approximately 11 sq.ft., which added to 72 sq.ft. of tubes gives 83 sq.ft. of heating surface for the shell and tubes for 1 ft. in length. Neglecting the heating surface of the tube sheets, the total heating surface is 1280 sq.ft. Then divide the total heating surface, 1280 by 83 sq.ft., which equals 1 ft. of heating surface in the length of the tubes and shell which gives the length of tubes and boiler as approximately 15 ft. 6 in. If the boiler is to be made with a flush front, it will be 15 ft. 6 in. long and contain 96 three-inch tubes at the same length. If the boiler is to have an overhanging front it will be necessary to have an 18-in. dry sheet for the smoke box, making the boiler 17 ft. long. Having determined the size of the boiler, it is necessary to decide on the material and pressure to be carried.

Boiler Plate

The Massachusetts boiler law requires shell plates to be made of fire-box steel and, as a boiler shell has nothing but its own cylindrical form and strength to sustain the pressure, the best fire-box steel should be used. The boiler is to be built for a working pressure of 150 lb., therefore, the longitudinal joints will be a quadruple-riveted butt joint with inside and outside covering straps, the joint to have an efficiency of 94 per cent. To determine the thickness of the shell, assuming a tensile strength of 58,000 lb. and a factor of safety of 5, which is none too low, and an efficiency of 94 per cent. We then have

$$\frac{\textit{Tensile strength}}{\textit{Radius} \times \textit{factor of safety}} \times \textit{efficiency} = \frac{58{,}000}{33 \times 5} \times 0.94 = 330.41$$

Dividing 150 lb. pressure by 330.41 will give the thickness of plate necessary, or 0.454, or a $\frac{15}{32}$-in. plate. Assuming that the height from the top row of tubes to the shell is 22 in. and using the Massachusetts boiler rules in calculating the segment, which is

$$\frac{4\,H^2}{3} \times \sqrt{\frac{2\,R}{H} - 0.608}$$

equals area of segment to be stayed, in square inches. Where

H = Distance from tubes to shell, minus 5 in.;

R = Radius of shell, minus 3 in.

The segment will contain 658 sq.in., which at a pressure of 150 lb. you will have

$$658 \times 150 = 98{,}700\ lb.$$

total pressure on that portion of the two heads.

Braces

A good weldless brace will have 7500 lb. tensile strength

equare inch up to and including 1¼ in. diameter or valent, and above that 8000 lb. can be safely allowed. me that a 1¼-in. brace is used, having a cross- onal area of 1.227 in., then 9202 lb. can be allowed ach brace. Dividing the total load on the heads by , it will be seen that more than ten braces are re- d, therefore, 11 braces will be used on each head. ne rivet strength of the braces must be in excess of ensile strength of the brace and all braces should be ed so as to have as direct a pull as possible and no e should be less than 46 in. in length.

Fittings

s regards the nozzles, avoid cast iron as much as pos- and use cast- or pressed-steel nozzle. Safety-valve steam-pipe outlets should be separate and if a dry is used, the safety-valve outlet should not be con- d to it. The blowoff flange should be of pressed To complete the boiler the necessary castings must btained, besides the brick work and foundation, viz., ront, grates, dead plate, arch and check plates, buck- and rods, anchor bolts, clean-out doors not less than 0 in., stack base and stack or chimney, also breech- to chimney, damper located in the breeching, wall s and rollers or, if preferred, instead of rollers un- he lugs use iron balls 1½ or 2 in. in diameter. This allow the boiler to expand freely in all directions. ne necessary fittings are 3½-in. pop safety valve, n gage graduated at least 1½ times the allowed r pressure, check and feed valves. The blowoff valves ld be 2 or 2½ in. in diameter. Then there are the r column and connections. Have the lower connec- of brass and use cross fittings instead of elbows, so in case the lower connections should fill up with , the plug in the cross can be removed and the pipe ned with a rod.

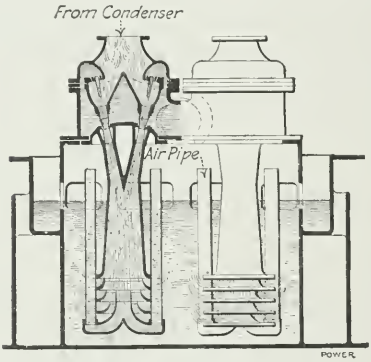
surface blowoff to rid the boiler of scum is advisable use in so doing the scale-forming impurities are re- d. for scale is nothing but floating matter and scum h finds its way to the tube and shell surface where lheres, but it can be blown out very easily with a nce blowoff while the boiler is in operation. Provide oiler with two methods of feeding and do not forget od, closed heater; it will pay for itself in less than a and if a closed heater is used, no grease can get into oiler.

Chicago to Have a 30,000-Kw. Turbine

ne Commonwealth Edison Co., of Chicago, has re- ly ordered a 30,000-kw. turbo-generator for its hwest Station. In the Fisk St. extension they installing at present a 25,000-kw. Parsons turbine, have also ordered a 20,000-kw. horizontal turbine the General Electric Co. The 30,000-kw. machine the Northwest Station will also be of the General tric horizontal type and similar to the unit for Fisk with the exception that the turbine will be designed separate high- and low-pressure cylinders, the lat- being arranged on the double-flow principle. The er unit will be somewhat more economical in steam umption. It will be equipped with a surface con- er having 50,000 sq.ft. of cooling surface, together with necessary auxiliaries, and a boiler equipment similar to the new units at Fisk St., described in the issue of Nov. 4 and on other pages of this issue. The generator, at a speed of 1500 r.p.m., will have a continuous full-load rating of 30,000 kw. at 100 per cent. power factor. Current will be generated at 9000 volts, 25 cycles. The exciter will be direct connected to the main generator shaft and will furnish current at 250 volts.

Kinetic Air Ejector

For the removal of air and noncondensable vapor from a condenser, the kinetic air ejector is a radical departure taking the place of the so called dry-vacuum pump used in a great majority of large condenser installations in this country. The particular ejector illustrated herewith was furnished by Messrs. Richardsons, Westgarth & Co., of West Hartlepool, Eng., for the condenser of the large 25,000-kw. Parsons turbine now being installed at Fisk Street Station, Chicago. It will be remembered



Kinetic Air Ejector

that this turbine and its condenser were described in our issue of Nov. 4. The ejector illustrated is made up into two units which can be used independently or together.

The ejector comprises a set of water jets annularly arranged which entrain the air and noncondensable vapors, removing them from the lower part of the steam space of the condenser. Water is pumped through these jets under a pressure of about 35 lb. per sq.in., by a centrifugal pump. The water is taken from the kinetic tank and from the nozzles discharged back to it, carrying the air with it on its return. Another centrifugal pump takes the water of condensation from the condenser and discharges it into the kinetic tank. The core of air formed in the column of water after entering the ejector is caught by a collecting pipe, by which it is discharged above the water level in the tank, and so obviates aëration of the feed water. Between the condenser and the kinetic nozzles there is a steam ejector which is used to augment the vacuum. This is not shown in the accompanying drawing, but appears in the article of Nov. 4.

The kinetic tank consists in reality of three sections; the middle section constitutes the kinetic tank proper, which has just been referred to. In addition to this, there is a tank on one side which performs the function of a feed-water heater and on the other side is a hotwell from

which the feed pumps take their supply. The hotwell is provided with a float connected to the makeup water supply, so that an adequate quantity of water will be maintained for boiler feed. The kinetic tank proper has an outside chamber into which the water overflows from the central chamber containing the nozzles. The water passes through a number of copper strainers and from this section flows to the feed-water heater. The water is heated by a number of steam jets which are supplied with steam from the connection between the high- and low-pressure cylinders on the turbine, or from the steam-driven boiler-feed pump. The heater section is connected to the hotwell by a passage running through the bottom part of the kinetic tank.

Should the supply of water in the hotwell tank be more temporarily than the demands of the boiler-feed pump, the excess will pass out through an overflow pipe which runs into a large reservoir located below the level of the basement floor. The use of this reservoir serves to save the pure water of condensation, which would otherwise be wasted. When the supply in the hotwell becomes deficient, a float valve in the hotwell serves to establish a connection from the reservoir into the condenser, thus furnishing the necessary makeup water. An additional float valve in the large reservoir serves to maintain the level at a predetermined height and admits water from the filtered water system in the station.

A number of official tests on the kinetic plant for the Commonwealth Edison Co. were made under the direction of Messrs. Merz & McLellan, of Newcastle-on-Tyne, Eng.

For the test the air-suction pipe was blanked off. The desired vacuum was maintained, and a known quantity of free air was admitted to the suction system through calibrated nozzles, with the same quantity of water at specified temperature passing through the pump as will pass through when it works in connection with the actual condenser. A remarkable feature in the results was that a vacuum of 29.8 in., with a barometer of 30 in., was maintained with an air admission of 14 cu.ft. per min., the temperature of the water passing through the jets being 74 deg. As 36 deg. is the temperature corresponding to a vacuum of 29.8 in., the water was actually 38 deg. warmer than the air. With an air admission of 160 cu.ft. per min., a vacuum of 28.6 in. was maintained with water at 85 deg. passing through the jets.

In some special tests made to determine the effect on the air withdrawing capacity of high-temperature water passing through the jets, it was found that 29 in. vacuum could be maintained with water at 130 deg., the air admission being 96 cu.ft. per min. The temperature corresponding to 29 in. of vacuum is 79 deg., so that the water was 51 deg. warmer than the air. Such a temperature is beyond what may be expected in practice, but the test well illustrates the flexibility and range of the apparatus.

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Steam Regenerative Accumulators

By H. Fothergill

Although steam-regenerative accumulators have been *high-pressure intermittent running reciprocating engines and low-pressure steam turbines; some features of design and a description of the Rateau-Morison type.*

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Although steam-regenerative accumulators have been employed in principle for at least 30 years, their practical use has been successful only since the advent of the low-pressure steam turbine.

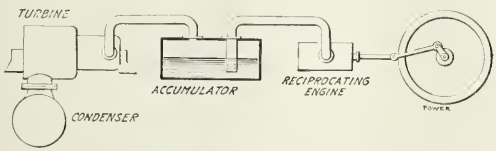


Fig. 1. Arrangement of Elementary Regenerator

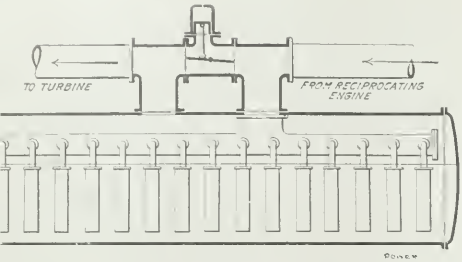
The application of the system lies chiefly in combining the steam turbine with intermittent running reciprocating engines, such as are used in rolling mills, colliery winding engines, etc., where the use of a continuous running high-pressure turbine as a substitute for the reciprocating engine would be impracticable. The exhaust steam from an intermittent running reciprocating engine cannot be used directly in a turbine as the exhaust is delivered in gulps which must be changed into a continuous supply at approximately uniform pressure. This transformation is effected by means of a steam-regenerative accumulator. Broadly speaking, a steam-regenerative accumulator is an apparatus which absorbs heat from steam delivered to it in intermittent quantities and gives up heat in the form of a continuous supply of steam of slightly lower pressure than the steam received.

When a steam turbine is supplied with exhaust steam from a high-pressure engine, such as a colliery winding engine, the quantity of exhaust discharged by the winding engine is at times greater than is required for driving the turbine, and it is the object of the regenerative accumulator to store up the heat in this surplus steam by condensing it in a body of water which gives it out again in the form of regenerated steam when the supply from the engine is insufficient for the turbine.

The system is illustrated diagrammatically in Fig. 1. Exhaust steam from the reciprocating engine passes into the water by which it is condensed, the water being thereby heated. When the water is raised to the same temperature as the exhaust steam, the steam passes through the water to the steam turbine, and when the supply of exhaust steam ceases, the turbine by continuing to draw from the steam space reduces the pressure and causes the water to boil, whereby a supply of regenerated steam continues to pass to the turbine; the water being again raised in temperature every time exhaust steam is delivered from the reciprocating engine.

There are several disadvantages in accumulators wherein the whole of the exhaust steam passes into the water. For example, there is a constant difference between the pressure in the exhaust-steam supply pipe to the accumu-

and the pressure in the outlet pipe from the accumulator to the turbine, the pressure difference being al to the resistance offered by the head of water in



IG. 2. PART OF STEAM PASSED DIRECT TO TURBINE

accumulator through which the steam must be passed. s resistance causes a drop between the initial pressure he turbine and the pressure in the exhaust-steam supp pipe to the accumulator. This drop is equivalent to ss of energy. Again, when the whole of the exhaust m must pass into the water, the first effect produced the exhaust steam is the gradual heating and the dual evaporation of the water in the accumulator. s continues until the temperature of the water in the mulator corresponds to the steam pressure which is essary for driving the turbine, the response of the bine to the supply of exhaust steam from the recipro ng engine at starting is therefore delayed.

The writer has found from experiment that higher effi ncy is obtained if a controllable portion of the exhaust m from the reciprocating engine is passed direct to steam turbine as illustrated in Fig. 2. It will be seen n this that the exhaust-steam supply pipe to the ac mulator is connected to the steam-supply pipe to the bine by a valve that is operated by a piston con led by the pressure of the exhaust steam from the procating engine, so that under normal conditions the ve is open, but when a predetermined pressure is ex led the piston is forced upward and the valve closed. erefore, at all pressures below that corresponding to resistance offered by the head of water above the zles in the accumulator, the steam flows freely to the bine so that the loss of pressure which must result ere the entire steam passes into the water, is avoided. o, when starting, a portion of the steam which flows t the control valve fills the steam space of the ac mulator and raises the pressure considerably above that responding to the temperature of the water in the ac mulator; consequently all the heat in the steam sup ed through the nozzles is absorbed by the water and evaporation takes place until its temperature reaches temperature corresponding to the pressure in the m space. This rapid absorption of heat by the water the accumulator in addition to and in parallel with supply of steam to the turbine through the control ve causes a total consumption of steam in a given e greater than in the ordinary system. This greater sumption takes place just at the time when the maxi m quantity of steam is discharged by the reciprocat engine and as a consequence the loss of surplus steam ough the safety valve is minimized.

In the working of a colliery winding engine, the period of acceleration is about one-fifth the total period, so that during acceleration the amount of exhaust steam may be many times the average and drop off to nothing before the winding is completed. In rolling-mill work the effect is similar, but the periods are shorter. The duration of the stops to be bridged varies for different services, but in the majority of cases may be taken at 60 sec. in colliery work, and from 30 to 45 sec. in rolling-mill work.

The pressure range over which an accumulator is designed to work is usually taken from 17 to 14 lb. per sq.in. absolute, corresponding to a temperature range of 10 deg. F. so that the pressure in the accumulator will be continually varying from above atmospheric pressure to slightly below, there being periods of pressure and periods of partial vacuum, the partial vacuum never exceeding 3 in., thus leaving a minimum range of from, say, 3 to 28½ in. in the turbine, while at times the pressure at the turbine inlet may be 2 lb. above atmospheric.

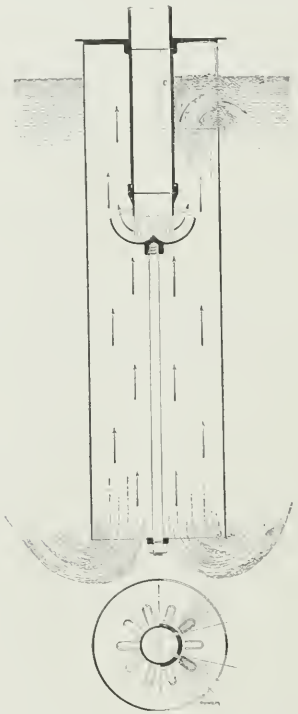


FIG. 3. SECTION THROUGH EXHAUST NOZZLE

The calculations for a steam-regenerative accumulator are comparatively simple.

Let,

W = Pounds of steam required per second for the turbine;

w = Pounds of water in the accumulator;

T = Time of stop in seconds when the reciprocating engine is not working;

t = Temperature rise in the accumulator water,

usually about 10 deg. F.:

H = Total heat per pound of steam in the accumulator, above the temperature of the water, which equals approximately the latent heat.

Total heat of steam regenerated from the water during

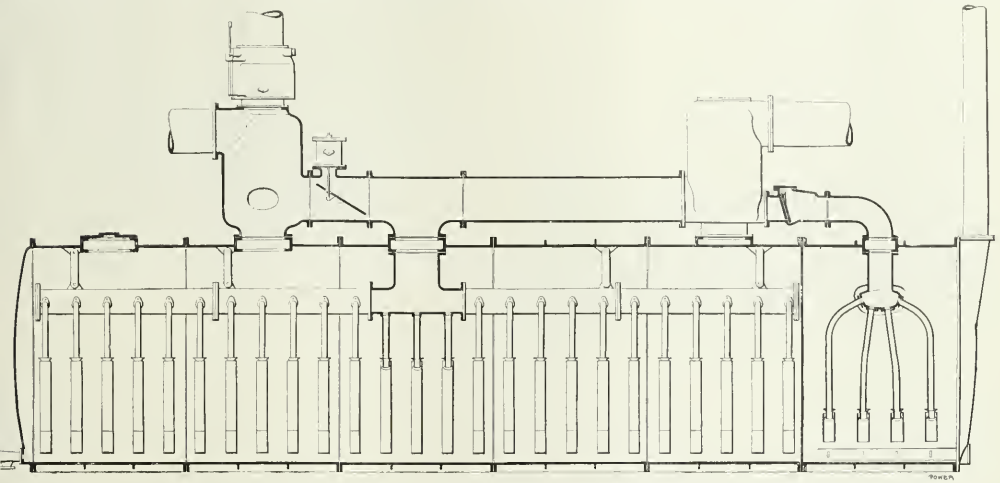


FIG. 4. COMBINED STEAM REGENERATOR AND FEED-WATER HEATER

oppage of reciprocating engine $= WTH$.

This quantity of heat has to be stored by the water in ie accumulator.

Total heat stored by the water $= wt$.

Hence, $WTH = wt$

$$w = \frac{WTH}{t}$$

From this equation it is seen that the capacity is independent of the time of absorption; but in order to obin maximum efficiency it is necessary for the whole ody of contained water to be at a uniform temperature hen regeneration commences. Therefore, in order osely to approach this ideal result, a very effective methl of circulating the whole mass of water must be adopted. It has been found by employing multiple heating nozes so constructed that the surplus steam is discharged om them in narrow sheets in an upward direction, that eam is easily condensed by the surrounding water and the same time produces maximum circulation through e pipes in which they are placed. In this way the large lume of steam coming from the high-pressure engine so divided up and distributed throughout the accumutor that the disturbance caused by the hot steam meetg the water is practically of no account and this perits the steam outlets to be placed very close to the surce of the water without causing any violent ebullition the surface and producing priming or wet steam. A eat advantage obtained by reducing the depth of water ove the steam outlets, is that the resistance to flow rough the nozzles is correspondingly reduced.

After exhaustive tests involving a large number of degns the arrangement of nozzle placed within a verical circulating tube, as shown in Fig. 3, has been adopted the Rateau-Morison accumulator.

In plan the nozzle is in the shape of a star having radial arms, each of which is provided with a narrow slot on its upper surface through which the steam passes in films, thereby exposing a large surface to the upwardly induced streams of water that flow between the arms. The nozzle is placed about 9 in. below the water level, and the steam supply is by a tube connected to the main steam-supply pipe which is situated in the steam space of the accumulator. There can be no short-circuiting of the water with this arrangement, as the entire volume within the effective range of the tube is compelled to travel from the bottom to the top.

In the practical working of accumulators the presence of oil on the water has been found to have a detrimental effect. It will be noted that the circulating device illustrated in Fig. 3 is provided with a water outlet at the top at one side only, and as the discharge from each water-circulating device is in one direction, viz., toward the end of the accumulator, a current is set up which continuously and effectively forces oil, scum and all floating impurities toward one end into a collecting chamber, from which it is drained away periodically or continuously as may be desired.

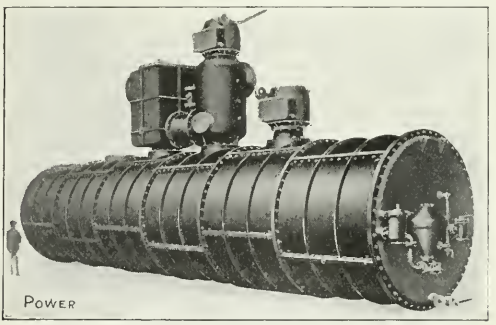


FIG. 5. EXTERIOR VIEW OF RATEAU-MORISON ACCUMULATOR

In combined reciprocating-engine and steam-turbine plants wherein the supply of exhaust steam is considerably greater than that required by the turbine, a very convenient way of utilizing the surplus steam is for feed-water heating. Fig. 4 shows in section a combined steam-regenerative accumulator and feed-water heater. The heater is placed at the right-hand end of the accumulator and is connected by a nonreturn valve to the exhaust-steam supply system, the nozzles in the heater being submerged at a much greater depth than the nozzles in the accumulator, so that the exhaust steam preferentially flows through the nozzles in the accumulator but when there is a surplus supply, then the pressure rises and steam passes through the nonreturn valve into the heater.

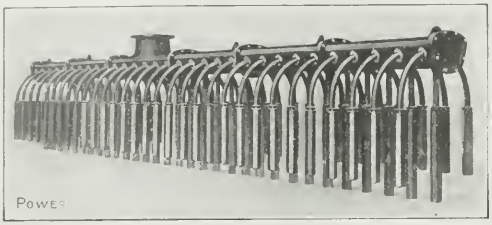


FIG. 6. INTERNAL WATER-CIRCULATING TUBES

Fig. 5 is a photograph of a modern accumulator of the Rateau-Morison type. On the top of the accumulator are shown the exhaust-steam inlet, oil-separating chamber, bypass valve, outlet dome and safety valve, and Fig. 6 shows the internal water-circulating tubes.

Test of a Welded Boiler

In connection with our report of the convention of the N. A. S. E. we mentioned briefly a test made by The Welding Co. of Springfield, Mass., of a rivetless boiler. We are able now to present reproductions of photographs of the boilers as taken under test by A. D. Risteen, of the Travelers' Insurance Co. It is of the vertical firebox type, designed to carry only 10 lb. pressure, 30 in. in diameter, made of ¼-in. flanged steel, and put together by oxyacetylene welding. Fig. 1 shows the longitudinal joint; Fig. 2 shows how the head or upper tube sheet

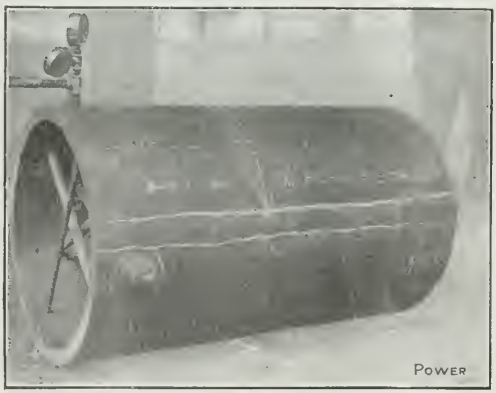


FIG. 1. WELDED LONGITUDINAL SEAM

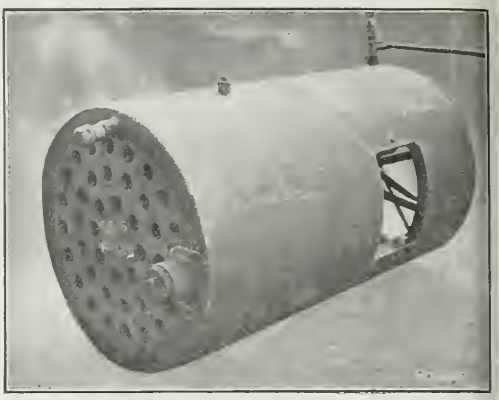


FIG. 2. TUBE SHEET WELDED IN

and door frame are welded in. On account of the low pressure for which the boiler is designed the water leg was not stay-bolted, and to oppose the tendency of the inner sheet to bulge under the high pressure of the test, it was braced by rods placed irregularly in the firebox which was 26 in. in internal diameter and 24 in. in height. These rods were not, however, so arranged as to

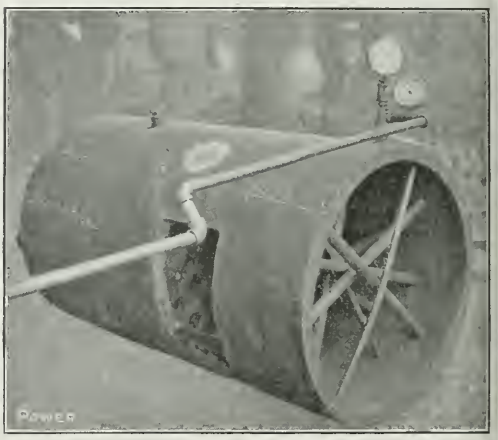


FIG. 3. FIREBOX END, SHOWING TEMPORARY BRACING

prevent distortion, and at 310 lb. the inner sheet of the water leg had bulged inward so badly that it tore away from the door frame and allowed a leak which made it impossible to carry the pressure higher. The longitudinal and other seams stood the pressure perfectly. It is proposed to stay-bolt the water leg and repeat the test under conditions which will put the welding itself to the test.

To Regulate the Price of Water Power to consumers, the national government has established a new policy in granting water-power permits. A maximum charge of 6c. per kw.-hr. is fixed by the terms of the permit, and the lower the power rate charged by the company, the lower will be the water rate collected by the government. Lower rates on water are to be charged for power used for certain purposes, such as making nitrates for fertilizers and decreasing rates as more power is developed. This will not only protect the consumer, but encourage the fullest development of water power.

ELECTRICAL DEPARTMENT

The Induction Motor—III

By F. A. Annett

Wound Rotor

At the instant of starting, the simple squirrel-cage induction motor acts very much like a potential transformer with the secondary short-circuited; that is, when the rotor is at rest the electromotive force induced in it is at a maximum and the frequency is the same as the stator winding, consequently, since the resistance of the rotor is low the current will be large at a low power factor, causing the stator winding to take a large current from the line with a correspondingly low power factor.

The starting torque of an induction motor is influenced to a very large degree by the angle of lag between the current and the e.m.f. in the rotor, being at a maximum when the two are in phase and at zero when the current is lagging 90 deg. Since the phase relation between the current and the e.m.f. in an alternating-current circuit depends upon the resistance and the reactance of the circuit, the two being nearly in step when the reactance is small and the resistance high and differing in phase nearly 90 deg. when the reactance is high and the resistance low, it is evident that to provide a good starting torque the resistance of the rotor should be high and the reactance low; but high-resistance rotors decrease the efficiency of the motor when running, therefore, to get the best operating results the rotor should have high resistance at starting and low resistance when running. This condition is frequently secured by the use of a wound rotor connected to an external resistance, a motor of this type permitting easy speed adjustment as will be explained later.

This type of rotor instead of being wound with bars which are short-circuited at each end as in the squirrel-cage type has a winding of insulated wire similar to the winding used on the armature of a three-phase alternator, the polar spacing depending upon the polar spacing of the stator winding. This winding is connected in series with an external resistance at starting which is cut out as the rotor comes up to speed.

It is well known that the torque of a wound-rotor motor fluctuates greatly, depending upon the position of the rotor winding with respect to that of the stator. This fluctuation increases as the current increases and the smaller the number of phases in the rotor. For this latter reason the three-phase winding is used exclusively on the rotors of all polyphase wound-rotor induction motors whether the motor is built for a two-phase or a three-phase circuit. This fluctuation is also present in the squirrel-cage motor, but to a very small degree as the number of phases in the rotor is very great.

Wound rotors are built in two general types, those that have the starting resistance and short-circuiting switch mounted within the rotor, and those that have the starting resistance and cutout switch mounted outside the motor.

Fig. 19 shows a G. E. wound rotor in which the resistance is made in three parts, one part for each phase, and consists of cast-iron grids inclosed in a triangular frame which is bolted to the end plates holding the rotor laminations together. It is short-circuited by sliding laminated spring metal brushes along the grids. These brushes are supported by a metal sleeve upon the shaft which is operated by a rod that passes through the end of a hollow shaft and engages the brush arrangement in the rotor. The outer end of this rod terminates in a loose knob as shown, and by pushing in the knob when the motor has attained its speed the resistance is cut out. In the larger-sized motors the resistance is cut out by a lever secured to the bearing bracket. These resistances are made in three different forms: Cast-iron grids, cast-brass grids and cylindrical coils made from a german-silver strip wound on its edge. In all three forms the resistance is cut out in a way similar to that explained.

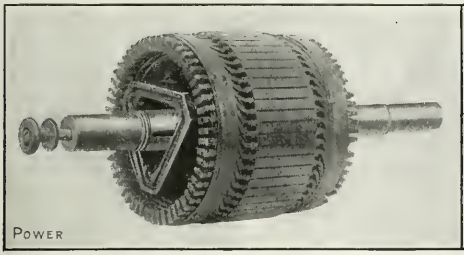


Fig. 19. G. E. Wound Rotor

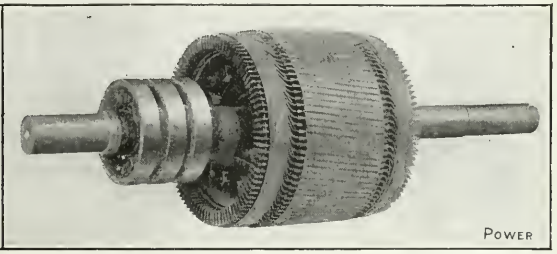


Fig. 20. Rotor Having External Resistance

If the resistance is to be cut out at a distant point from the motor, or the motor is to be used for variable-speed service it is best to mount the resistance and controller external from the motor. This necessitates the use of three collector rings, insulated from each other and keyed to the shaft. Fig. 20 shows a G. E. rotor of this type. These collector rings connect the rotor winding to the controller and resistance through brush gear provided for that purpose.

Fig. 21 shows diagrammatically the rotor winding connected to the starting resistance through the collector rings and brushes. The three rotor windings A, B and C are connected in star, and the terminals of the windings are connected to the three collector rings. The three branches R_1, R_2 and R_3 of the starting resistance are also connected in star by the three-armed short-circuiting switch S. At starting the arm is in the position shown by the full lines and all the resistance is in series with the rotor winding. As the rotor comes up to speed the arm is gradually moved around in the direction indicated to the position shown by the dotted lines. At this position the resistance is all cut out and the three rotor windings are short-circuited by the arms of the switch. By using three resistances, one in each phase of the rotor, and a short-circuiting switch, as shown in Fig. 21, the resistance in each phase is kept balanced, and, consequently, the current for the different starting points, although this is not absolutely necessary except at the point of maximum starting torque.

In most cases satisfactory starting can be obtained by using what is known as an unbalanced resistance, as shown in Fig. 22. Two resistances R_1 and R_2 are connected in open delta at starting by the arm S in the position shown by the full lines, as the motor comes up to speed the arm is gradually moved around to the position indicated by the dotted lines at which position the resistance is all cut out and the rotor windings are short-circuited. With such a connection the current in phase C is greater than in phases A and B for all starting points, the current in each phase becoming nearer balanced as the resistance is decreased until the rotor windings are short-circuited, at which point the conditions are the same as in Fig. 21. This unbalancing of the current has so little effect that it is unobjectionable for most starting purposes.

The Bell Electric Motor Co. manufactures an interesting type of polyphase induction motor, the rotor of which has a high resistance at starting and a low resistance when running. A winding similar to that used on the armature of a direct-current motor is placed in the bottom of the rotor slots and connected to a commutator, as there is no external circuit provided for this winding no current will be set up in it at starting. A second winding similar to a squirrel-cage winding of high resistance is placed in the top of the slots. At starting this winding acts like that of a regular squirrel-cage motor except on account of the high rotor resistance the starting current taken from the line is considerably reduced, and the starting torque increased. When the rotor comes up to speed a short-circuiting device mounted on the shaft at the outer end of the commutator is thrown in by a centrifugal governor and short-circuits the coils of the winding in the bottom of the slots through the commutator, making this winding similar to the squirrel-cage winding and thus reducing the resistance of the rotor. At running the rotor is similar to one that has two squirrel-cage windings in parallel. The commutator is used for no other purpose than to provide a ready means to short-circuit the winding, thus making the motor automatic in its starting and requiring no attention other than closing the line switch at starting and opening it again when the motor is stopped.

The Wagner Electric Manufacturing Co. builds a wound-rotor polyphase induction motor that is also automatic in starting. The rotor winding is similar to that used on a direct-current armature and is connected to a vertical commutator, this winding is so connected that the coils are in series at starting and thus increase the rotor resistance. After the rotor has attained the proper speed a short-circuiting device mounted within the rotor is thrown in by a centrifugal governor and the rotor is then running as one of the squirrel-cage type. The stator winding is the same as that used in any polyphase motor. This type of motor is well adapted to remote control, requiring no controlling device other than a single-throw three-pole switch to open and close the line circuit and a double-throw switch if the motor is to be reversed.

To Reverse the Direction of Rotation

To reverse the direction of rotation of a two- of three-phase induction motor it is necessary to reverse the direction of the revolving magnetic field. In a two-phase motor this can be done by crossing the terminals of either phase with the terminals of the motor, and a three-phase motor can be reversed by crossing any two terminals. The following diagrams will make this clear:

Fig. 23 represents a two-phase induction-motor winding connected to a four-wire, two-phase circuit; crossing the connection of phase A or B, as shown in Fig. 24, will reverse the direction of rotation. Fig. 25 represents a two-phase motor connected to a three-wire, two-phase circuit. The voltage E across each phase is the same, but between the two outside legs it is $E\sqrt{2}$. The motor under this condition can be reversed in two different ways, first as shown in Fig. 26, by crossing either of the phase terminals in the motor, which leaves the connections with respect to the e.m.f. as they were at first. The second method is shown in Fig. 27 and consists in

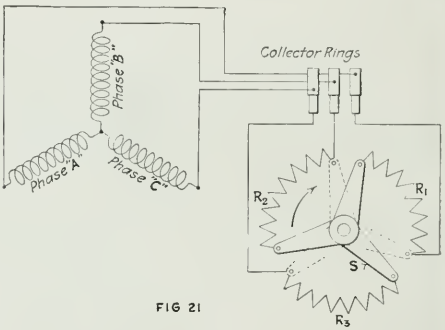


FIG 21

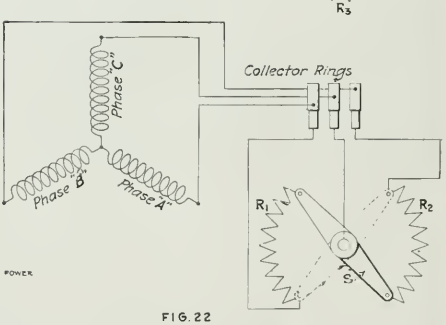
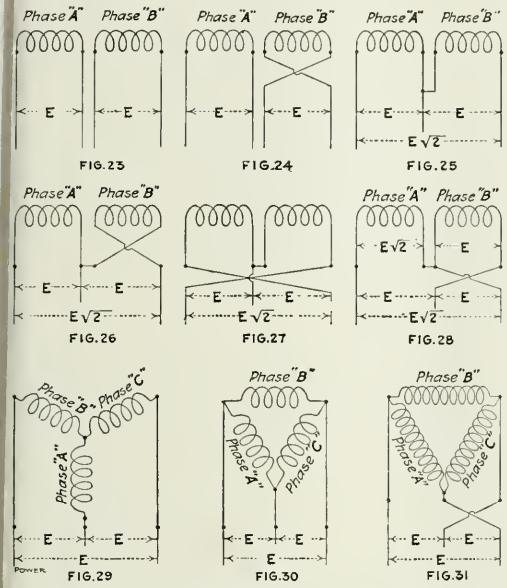


FIG. 22

Balanced and Unbalanced Starting Resistances

rossing the outside line terminals. This gives the same voltage relation with reference to the two different windings, that is, there is E volts across phases A and B and $E\sqrt{2}$ across the two outside terminals. Care should be taken not to connect a two-phase motor, as shown in Fig. 28, as this gives an excessive voltage across one phase which changes the phase relation of the current in the



Connections for Reversing Both Two- and Three-Phase Motors

two windings and reduces the starting torque, also the excessive current is liable to burn out the windings in a very short period.

In Fig. 29 is shown diagrammatically the windings of a three-phase motor connected in star to a three-phase circuit. The voltage is the same between any two-line wires, and between any two terminals of the motor there are two windings connected in series. Hence, any two of the line terminals can be crossed with respect to the motor terminals and have the same relation between the line voltage and the windings in the motor. This also holds true for the delta connection shown in Fig. 30; in this connection, however, there is only one winding across each phase and to work on the same voltage as the star connection will require seven-tenths more turns in each winding than required when the windings are connected in star. Crossing any two of the line terminals, as shown in Fig. 31, with respect to the motor terminals will reverse the direction of rotation.

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Occupation of Graduate Engineers—In an interview published in the "New York Times," Oct. 18, Professor Furman of the Stevens Institute of Technology reviews the careers of graduates of that school of mechanical engineering and furnishes diagrams showing that of men graduated 15 to 20 years, about 42 per cent. are filling positions as executive officers, managers, etc.; about 18 per cent. occupy executive positions as superintendents and heads of manufacturing departments and about 5 per cent. are retired or unaccounted for.

Necessity for Good Voltage Regulation

By Cornelius Weber

The importance of good voltage regulation will be apparent from the following few facts which point out the financial loss encountered by line drop or a high-reading voltmeter.

Assume, for example, that a central station in a small town serves 800 incandescent-light customers and that the average kilowatt-hour consumption per customer per month is 20. This corresponds to an average burning of four 40-watt lamps for 4 hr. each evening, a total of 512 kw.-hr. per night with normal voltage at 110. This kilowatt-hour consumption per evening amounts to 188,800 kw.-hr. per year and, at 10c. per kw.-hr., represents the sum of $18,880.

Now suppose that, due to line drop or a high-reading voltmeter, or a combination of both, the average actual voltage on the incandescent-lamp circuits is only 105, so that the voltage is 95.5 per cent. of normal. Under these conditions the wattage output is only 91.2 per cent. of normal, as the wattage input on resistance loads such as incandescent lamps varies as the square of the voltage. In other words, this loss of five volts causes a loss of 8.8 per cent. in kilowatt-hour consumption and, in the foregoing example, represents $0.088 \times 18{,}880 = \$1661.44$. This decrease in revenue is practically a total loss.

Electric cooking utensils, flat-irons, etc., behave in a similar manner to incandescent lamps and when operating below normal voltage cause losses in revenue in the same way. This is not true, however, of electric motors, as these have, for a given load, practically a constant wattage input even with varying voltage within reasonable limits. However, motors are often the cause of heavy line drop and it is good practice as a rule to keep power and lighting circuits separate.

Aside from the actual financial loss caused by low voltage the lamps suffer a decrease in candlepower and efficiency. A 110-volt carbon-filament lamp burning at 105 volts or 95.5 per cent. normal voltage delivers only 74 per cent. of the normal candlepower while under similar conditions the tungsten lamp delivers about 83 per cent. normal candlepower. This readily accounts for dissatisfied customers and loss of business.

A well designed distributing system is invariably a well paying investment and station instrument inspection and calibration a matter of no little importance.

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Voltage Too High

We have three Westinghouse turbines direct-connected to alternating-current generators running at a speed of 3600 r.p.m. Two of the machines show a voltage of 2300 at 60 cycles, while the other one shows 2350 at 60 cycles. Now in trying to get the voltage down to 2300 the machine was slowed down to 56 cycles, but this did not make any difference in the voltage, it still being 2350. The rheostat on the machine was then cut in and out to the limit but still there was no change in the voltage.

Perhaps someone can account for this one machine acting in this manner. We have a vibration tachometer on each machine and a Terrill regulator on the system.

Wilford M. Stockwell.

Middletown, Conn.

GAS POWER DEPARTMENT

Exhaust Gases from Oils and Gas Fuels

By Julian C. Smallwood

The proportions of CO_2, oxygen and nitrogen resulting from the combustion of coal are fairly well known, so that one readily forms an idea of the efficiency of the process upon learning the percentage of CO_2. This, however, is not the case when the fuel is any of the fuel oils or gases.

The accompanying curves show the proportions to be expected, as would be indicated by an analysis with the Orsat apparatus, in the products of complete combustion of representative oils and gases using various amounts of air. Curves for carbon, anthracite and bituminous coal are included for comparison. The percentages of CO_2, O_2 and N_2 are shown vertically; and horizontally, the ratio of air used to that theoretically required for complete combustion, that is, the "excess coefficient."

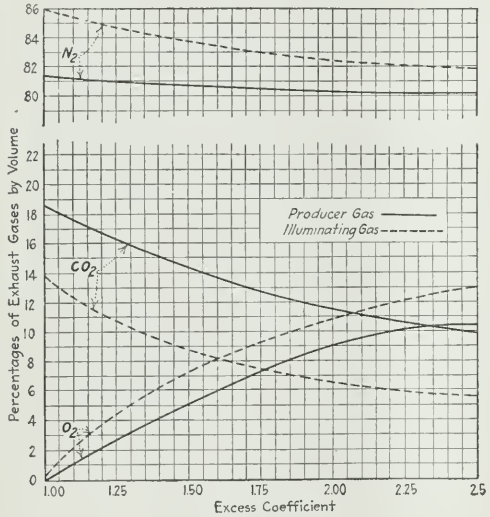


Fig. 1. Products of Combustion from Gases

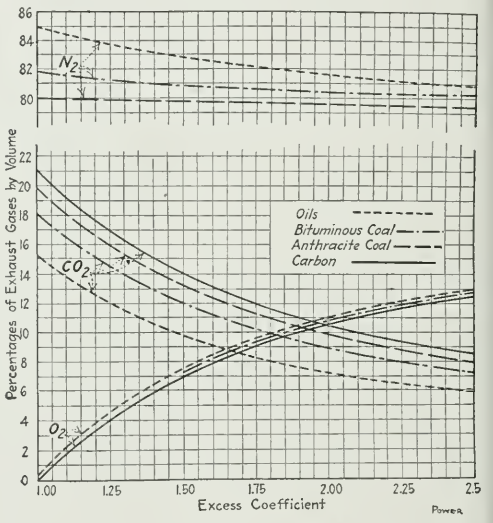


Fig. 2. Products of Combustion from Oils and Coal

The chemical analyses of the assumed fuels are as follows:

	Gas, Per Cent. by Volume		Oil, Per Cent. by Weight	Coal, Per Cent. by Weight	
	Producer	Illuminating		Anthracite	Bituminous
Carbon monoxide, CO	25	15			
Carbon, C			84	89	76
Hydrogen, H_2	12	45	14	2	5
Marsh gas, CH_4	2	25			
Olefiant gas, C_2H_4		3			
Benzol, C_6H_6		2			
Oxygen, O_2		1			
Carbon dioxide, CO_2	5	4			
Nitrogen, N_2	55	5			
Impurities, SO_2, H_2S, etc.	1	.	2	9	9

The constituents of each of these classes of fuels vary widely in proportions, according to manufacture or mine, except those of oil. In the various fuel oils, whether distillates or crudes, the percentages of carbon and hydrogen are remarkably similar, being between 82.5 and 85 per cent. C. and between 12 and 15 per cent. H_2. The products from the complete combustion of oils will therefore be in all cases nearly those shown by the curves for oil combustion. With the other fuels, however, the proportions of the products will vary somewhat according to the differences in the particular fuel analysis from those assumed for the curves.

The products of actual combustion will differ from the results shown by the curves if there is incomplete combustion. Carbon monoxide in the exhaust will lower the percentages of the other gases, and unburned hydrocarbons will appear as nitrogen and lower the percentages of the other products. Since the products of incomplete combustion in good practice are small, their effect to change the theoretical relations is not large.

In many cases it is of value to plot curves similar to those shown, assuming an average value of the fuel analysis. These curves furnish a ready check upon the efficiency of combustion in connection with actual exhaust-gas analyses, and also check the accuracy of the exhaust-gas analyses since any marked variation of the results from the proportions shown by the curves would indicate error.

For this purpose, the following formulas may be used for the combustion of oils and coals. These neglect the effects of the nitrogen, oxygen and sulphur in the fuels

as they are of small amounts and do not swell the products of combustion materially: Let

C = Percentage by weight of carbon in the fuel;

H = Percentage by weight of hydrogen in the fuel;

X = Excess coefficient.

Then, in the exhaust gas,

$$\text{Per cent. } CO_2 = \frac{C}{C + (4.75\,X - 1)(C + 3\,H)} \times 100$$

$$\text{Per cent. } O_2 = \frac{(X - 1)(C + 3\,H)}{C + (4.75\,X - 1)(C + 3\,H)} \times 100$$

$$\text{Per cent. } N_2 = 100 - \%\ CO_2 - \%\ O_2$$

To get the products of combustion to be expected from gas fuels, knowing the volume analyses, one must first calculate the quantities referred to below as c, A and T. Letting % CO, % H_2, etc., stand for the percentages of the fuel-gas constituents, as shown by the fuel-gas analysis,

$$c = \%\ CO + \%\ CH_4 + 2 \times \%\ C_2H_4 + 6 \times \%\ C_6H_6 + \%\ CO_2$$

$$A = 0.5 \times (\%\ CO + \%\ H_2) + 2 \times \%\ CH_4 + 3 \times \%\ C_2H_4 + 7.5 \times \%\ C_6H_6 - \%\ O_2$$

$$T = c + (4.75\,X - 1) \times A + \%\ N_2$$

Then, in the exhaust gas

$$\text{Per cent. } CO_2 = \frac{c}{T} \times 100$$

$$\text{Per cent. } O_2 = \frac{(X - 1) \times A}{T} \times 100$$

$$\text{Per cent. } N_2 = 100 - \%\ CO_2 - \%\ O_2$$

As an example of the use of these formulas, take the illuminating gas tabulated above, and assume 50 per cent. excess of air, that is, $X = 1.5$.

$$c = 15 + 25 + 2 \times 3 + 6 \times 2 + 4 = 62$$

$$A = 0.5 \times (15 + 45) + 2 \times 25 + 3 \times 3 + 7.5 \times 2 - 1 = 103$$

$$T = 62 + (4.75 \times 1.5 - 1) \times 103 + 5 = 698$$

from which the products of combustion are

$$\text{Per cent. } CO_2 = \frac{62}{698} \times 100 = 8.9$$

$$\text{Per cent. } O_2 = \frac{(1.5 - 1) \times 103}{698} \times 100 = 7.4$$

$$\text{Per cent. } N_2 = 100 - 8.9 - 7.4 = 83.7$$

Using the curves for a fuel in actual use, the amount of air consumed may readily be obtained from them if the percentage of CO_2 is found by exhaust-gas analysis. This is done by finding the value of the excess coefficient corresponding to the percentage of CO_2 from the curve, and multiplying the excess coefficient so found by the amount of air theoretically required for the complete combustion of 1 lb. or 1 cu.ft. of the fuel. This last quantity may be found from the following formulas, using the same notation as before.

For oils and coal, the pounds of air required per pound of fuel = 0.116 C + 0.348 H.

For gases, the cubic feet of air required per cubic foot of fuel $= \frac{A}{21}$.

When oil is burned under furnaces with air under pressure, very little excess air is needed for complete combustion. In internal-combustion engines, however, it is generally better practice to use dilute mixtures yielding low percentages of CO_2.

A Steam-Gas Power System

H. Ray, assisted by C. J. Smith, both of Toledo, gave an illustrated lecture on the above subject before Illinois Association No. 1, Chicago, of the National Association of Stationary Engineers on Oct. 15. The apparatus described consists of a boiler and engine, of special design.

The boiler is cylindrical in external form, upright in position and contains three sets of horizontal tubes or conduits. The tubes of any set are connected with each other in series by vertical lengths of the same diameter. The sets are arranged in vertical rows, the main set, communicating with the furnace, being in the middle.

The fuel employed is erude oil or any of its distillates. The furnace is located in the upper part of the shell with its top just below the water line in the boiler. The gases of combustion pass upward through a few horizontal lengths of fire tubes surrounded by steam, thence downward through the balance of the tubes, surrounded by water and out to the atmosphere at the bottom. Forced draft is employed in supplying air to the furnaces. In starting up with a cold boiler the gases of combustion are short-circuited through a conduit to a stack above the water. A conduit or retort, in the furnace, through which the oil is first passed, serves to vaporize and preheat the fuel before it is fed to the furnace.

The superheated steam yielded by the boiler is utilized in the crank end of a combination steam-gas engine. In the head end some of the oil volatilized in the furnace retort is used in the same way as in a four-stroke-cycle gas engine. The head end of the cylinder is jacketed and the water circulated therein is drawn from the lower portion of the boiler where the temperature is the lowest and discharged back to the boiler at a point where the temperature in the boiler corresponds with the temperature of the jacket discharge.

The exhaust from the gas end of the cylinder is passed through two sets of tubes which commence at the very top of the boiler and extend to the bottom in horizontal layers, passing first through the steam space and then through the water space. It is claimed that thus the gases first supply heat for superheating the steam and later help to heat the cool water below. The exhaust from the steam end of the cylinder is discharged into the same set of tubes as the exhaust gas and commingle therewith. The exhaust steam, however, instead of being admitted at the top of the tubes, is admitted at a point lower down where the temperature of the water surrounding the tubes is about 212 deg. The mingled exhaust gas and steam are discharged into a tank below the boiler and the steam, now condensed, is recovered for boiler-feed purposes while the gases escape through a vent.

The lecturers stated that a 100-hp. experimental unit showed a thermal efficiency of 60 per cent. No units have been built as yet for commercial use.

Two new fuel ships, the "Kanawha" and the "Maumee," are now under construction for the United States Navy. The former will have two, three-cylinder triple-expansion engines of 2600 hp. each and is being constructed at a private yard. The latter, however, will be propelled by two Nürnberg Diesel engines of approximately the same power as the steam engines in the sister ship. Although the hull of the Maumee will be constructed at the Mare Island Navy Yard the engines will be built at the Brooklyn Navy Yard from plans purchased abroad, and will be shipped to the Pacific coast.

These two ships will afford an excellent opportunity for determining the relative merits of oil and steam engines under like conditions.

REFRIGERATION DEPARTMENT

Thermal-Testing Plant of Pennsylvania State College*

By J. A. Moyer†

Less than a year ago the Pennsylvania State College established and equipped the largest and most elaborate thermal-testing plant in America, and during the short time the plant has been operating some interesting results have been obtained.

Every effort has been made to eliminate the difficulties usually encountered in testing materials to determine the rate of heat transmission. The calorimeter is roomy, so that large samples can be tested. The means are also available for measuring and varying the velocity of the air, and by means of accurate and delicate platinum resistance thermometers located in the calorimeter room, at the inside and outside walls of the material being tested, as well as on the surface and imbedded at various distances in the body of the material, it is believed very accurate determinations can be made.

The plant consists of two separate brick buildings. One building is 50x18 ft. and is used to house a complete 10-ton experimental refrigerating plant; the other building, which is the testing plant proper, is 32x32 ft. on the outside, and contains the calorimeter room which is 17x17 ft. This room is cooled to low temperatures by a number of rows of brine coils encircling the room. Cold brine is supplied from the refrigerating plant in the adjacent building through 2-in. heavily insulated pipes. Each of the materials to be tested is made up into a cubical box of approximately 150 sq.ft. of outside surface; and this box is then suspended in the calorimeter room for testing. An electric fan and an electric-heating coil are placed inside the box for producing the required uniformly distributed temperature difference between the inside and the outside of the box.

By this method tests can be made for a great range of temperature differences. Absolutely constant and uniform temperatures can be maintained for an indefinite period of time, and the heat put into the box per unit of time is measured by accurately calibrated voltmeters and ammeters on both the coil and the fan circuits. Direct current is used. Twenty platinum resistance thermometers are available for measuring the temperatures, inside and outside the testbox as well as in its walls. Cylindrical platinum coils are used for measuring the temperatures in all places except on the surfaces of the material, where thin platinum resistance disks less than 0.02 in. thick are firmly attached to the surface on their flat sides. Adopting the method of the U. S. Bureau of Standards the temperatures have been observed in each test in the following locations: (1) 2 ft. from the surface of the material tested, inside and outside; (2) 1 in. from the surface, inside and outside; (3) on the inside and outside surfaces by absolutely close contact; (4) at every inch of thickness through the material, also with thin flat platinum resistances which can be accurately located.

Air velocities outside the testbox were varied by the use of six variable-speed ventilating fans. Some of the most important data obtained during the last year are presented briefly in the following:

Table 1, giving the results of tests of a cork-board cube, shows the effect on the heat transmission of varying the air velocity over the outside of the surface of the box.

TABLE 1. VARIATION OF HEAT TRANSMISSION WITH AIR VELOCITY

Air Velocity Ft. per Min.	B.t.u. per Sq.Ft. per Deg. F. Diff. per Hr.
222	0.130
298	0.133
437	0.137
800	0.159
898	0.169
900	0.170
905	0.170

These data show that the transmission is increased about 34 per cent. as the velocity of the air is varied from 222 ft. per min. to 905 ft. per min., or the transmission is changed 5 per cent. per 100 ft. per min. change in velocity. In all these tests the velocity of the air inside the box was approximately 200 ft. per min. Velocities were measured with a carefully calibrated anemometer.

Tests made to show the change of transmission with variation in humidity showed the results given in Table 2.

TABLE 2. VARIATION OF HEAT TRANSMISSION WITH HUMIDITY

Relative Humidity Per Cent	B.t.u. per Sq.Ft. per Deg. F. Diff. per Hr.
70	0.170
76	0.171
84	0.173
90	0.174

By increasing the humidity from 70 to 90 per cent. the transmission is increased 2.4 per cent., which is equivalent to a change of 1.2 per cent. in transmission for a variation of 10 per cent. in humidity. Velocity of the air outside the box was 900 ft. per min.

The most remarkable effect of velocity on heat transmission is shown by the data in Table 3, for the temperature drop in passing from the interior of the cork-board box to the outside. The cork-board was 3 in. thick. The data represents the average of six consistent tests, some of which were continued for 20 hr. The velocity of the air inside the box was 200 ft. per min. and that outside was 950 ft. per min. in one case and practically zero in the other.

The effect of air velocity on the temperature gradient within the cork-board walls is remarkable, and every precaution has consequently been taken to check the results. About 25 different tests have been made on the cork-board and also on cubes of other building materials, and the same general effect has been observed. In the case of a single thickness of glass, the temperatures on the inside and outside surfaces are practically the same for a total temperature difference of 55 deg. F., showing that the glass itself has practically no heat-insulating properties. With practically "still air" outside the glass box and with this total range, there is a difference of 28 deg. between the temperature of the surface and the temperature

*Abstract of paper read before the Third International Congress of Refrigeration.

†Professor in charge of Pennsylvania Experiment Station.

TABLE 3. VARIATION OF HEAT TRANSMISSION THROUGH 3-IN. CORK-BOARD

Locations of Thermometers	Air Velocity 600 Ft. per Min. Reading of Ther.	Air Velocity 600 Ft. per Min. Temp. Diff.	Practically Still Air Reading of Ther.	Practically Still Air Temp. Diff.
1. Air inside box*	117.5		117.8	
2. Air 1 in. from inside surface	116 5	1 0	117.0	0 8
3. Inside surface of cork-board	113 5	3 0	114.0	3 0
4. Temperature in cork-board 1 in. from inside surface	86 5	27 0	94.0	20 0
5. Temperature of cork-board 1 in. from outside surface	57.0	29.5	66.5	27.5
6. Outside surface of cork-board	48.0	9 0	51.5	15 0
7. Air 1 in. from outside surface	47.5	0.5	47 5	4.0
8. Air outside box*	46.5	1.0	46.5	1.0

* Thermometer located 2 ft. from cork-board wall.

registered by a thermometer located at a distance of 1 in. from the surface. On the other hand, with a velocity of 600 ft. per min., this difference is 10 deg.; and with a velocity of 950 ft. per min., the difference is only 7 deg. In view of this great variation between the temperature at the surface and the temperature registered by a thermometer located close to the surface, it seems to be necessary that a definite standard location be adopted for measuring the temperature difference in heat-transmission tests and calculations. Since only specially designed and expensive thermometers are adaptable for measuring surface temperatures, the location recommended by the U. S. Bureau of Standards; that is, at 1 in. from the surface, should be generally acceptable.

Table 4 gives a number of values of heat transmission as determined in the plant described. The temperatures were observed at 1 in. from the inside and outside walls, and the velocities were in all cases about 200 ft. per min. Humidity was about 80 per cent.

TABLE 4. UNIT HEAT TRANSMISSION FOR VARIOUS MATERIALS

B.t.u. transmission per sq.ft. per hr. per deg. F., difference in temperature of air	
1-in. common brick	4 66
One 4-in. hollow tile	0.625
1-in. concrete (1-3-5 mix.)	4 29
¾ in. lumber (t and g)	0 83
One air space (from 1 in. to 6 in.)	1 66
1-in. mineral wool (dry)	0. 666
1-in. building paper	0. 30
1-in. pitch	0. 79
1-in. shavings (dry)	0. 666
1-in. granulated cork	0. 479
1-in. hair felt	0. 31
1-in. indurated fiber board	0. 416
1-in. compressed mineral wood board	0. 33
Single window (all glass)	1. 09

Present Status of the Refrigerating Industry in America*

By S. S. Van Der Vaart

In a glance at the present status of the refrigerating industry in America, one is struck by two points of salient interest to those engaged in industries utilizing artificial refrigeration. One is the gradual, and during the past few years, rapid extension of the ice-manufacturing industry northward into the domain heretofore thought to be the prerogative of natural ice, so that today great ice-manufacturing establishments are being erected in Portland, Maine; Boston, Mass.; and in Montreal, Toronto, Winnipeg, Calgary and other cities in Canada. In New York City, where in 1904 less than 20 per cent. of the total amount of ice consumed was manufactured ice, by 1913 the ice machines furnished practically 65 per cent., and when plants now under construction or planned for erection during the coming winter, are completed, the proportion will be nearer 75 per cent. manufactured to 25 per cent. natural ice. In cities like Dubuque and Sioux City, Iowa, and Minneapolis and St. Paul, Minn., where natural ice is abundant, easily obtained and cheap, ice-making plants have been or are being erected.

In regard to the opening of new fields for the use of refrigerating machinery, it is only necessary to point out the use of refrigerating machinery in the laundry to cool the starched collars and cuffs after leaving the mangle and before they are passed through the shaper. Another instance of new use for refrigerating machinery is found in the mining and metallurgical industries. In the process of treating ores with chlorine gas on a large scale, the recovery and condensation or liquefaction of the chlorine becomes essential. The liquefaction of chlorine gas at atmospheric pressure takes place at —29 deg. F., and the recent installation of a refrigerating plant capable of liquefying 850 lb. of chlorine gas per hour is reported from a Western mining field. Again, it was found that with the aid of refrigeration it is possible to extract gasoline from natural gas. In the paper-making industry refrigerating apparatus is being used to some extent to control temperatures during the treatment of the pulp and in such operations as the manufacture of wax paper from plain tissue paper.

The use of refrigerating machinery in testing delicate machinery, such as automobile parts, gasoline motors, or complete motor cars, has been tried recently with valuable results. A room is provided where temperatures of zero Fahrenheit or below can readily be maintained and here the performance of the machine is tested under the equivalent of winter conditions and with different grades and kinds of fuel in order to determine beforehand what particular combination produces the greatest efficiency.

An interesting extension of existing fields is in the preservation of the delicate ferns that grow in great abundance in the forests of Massachusetts, New Hampshire and Vermont and are in great demand in the Eastern cities for decorative purposes during the holiday season. In a New York zoölogical park, refrigeration is used to retard the opening of cocoons of rare and beautiful insects and moths, so that their short-lived beauty may be shown in the parks throughout the entire summer season.

Refrigeration is found to be advantageously applied in the preservation of seeds, such as apple and other fruit seeds, including also seed potatoes and grains. The fruit seeds are frozen and held at freezing temperatures, and seed potatoes and grains at temperatures just above the freezing point of water. The freezing of fresh, ripe berries and also cherries, and holding them in the frozen state until ready for use, is an application recently introduced and used by bakers and others.

Among other new applications of refrigeration is its use in the shipment of date-palm shoots or cuttings, also its use for curing or preventing tropical diseases and in some cases apparently curing the distressing affliction known as "hay fever."

In the field of invention, the development of the so called "flooded freezing system," or gravity feed of liquid refrigerant through the freezing coils in ice tanks, has reached quite general application. The removal of coils in the freezing tanks and the substitution of a brine cooler laid in one end of the tank through which all brine is circulated, is another recent development. The several systems of producing clear crystal ice from raw, or undistilled, water have reached practical development, and

*Abstract of paper read before the Third International Congress of Refrigeration, Chicago.

a number of raw-water ice-making plants are now in operation or being installed. Recent improvements in construction of ammonia condensers have resulted in considerably greater efficiency of this important portion of the refrigerating plant.

A brief survey of the development of the refrigerating industry in America will give some idea of its magnitude at the present time. It may be added that refrigeration is today still at its high-water mark of growth and extension. The latest available authentic statistics indicate that there are about 3500 ice-manufacturing establishments in the United States, equipped with machinery capable of producing between 18,000,000 and 20,000,000 tons of ice annually. The latest census reports gave the number of ice factories as 2004 in 1910, but this covers only those engaged primarily in ice making. There are many meat packers, brewers and others engaged primarily in other lines that also operate ice-making plants—some of these of very large capacity—which partly accounts for the wide discrepancy between the census report and the facts as they exist. The capital invested in the ice-making industry proper is estimated at not less than $150,000,000.

Cold storage includes so wide a field that it is difficult to estimate even the number of places where cold storage on a large or small scale is carried on, for at least 2000 meat markets have cold-storage rooms cooled with refrigerating machinery; about 1100 creameries, dairies and cheese factories are so equipped; about 350 ice-cream factories and about 350 produce dealers have cold-storage rooms equipped with refrigerating machinery. Again, in the fruit industry there are many hundreds of small cold-storage establishments scattered throughout the country, where fruit is held for short or long periods under refrigeration, and adding to all these between 800 and 900 commercial cold-storage warehouses, varying in capacity from 25,000 cu.ft. to 11,250,000 cu.ft. capacity, which is the capacity of the largest single cold-storage house in America, and some idea is gained of the vast extent of cold storage at its present state of development.

A list of the principal users of refrigerating machinery in the United States would include the following: 3500 ice-making plants, 1300 breweries, 600 packing houses and abattoirs, 2000 meat markets, 1100 creameries, dairies and cheese factories, 700 hotels, 1000 fruit-storage houses, 350 produce commission houses, 320 office and public buildings, 300 provision dealers, 300 liquor stores, 300 hospitals, 300 candy makers and confectioners, 250 restaurants, 250 schools and colleges, 200 groceries, 160 apartment houses and residences, 150 fish-freezing and storage houses, 150 oil and lard refineries, 100 carbonated beverage manufacturers, 100 bakeries, 100 club houses, 50 fur-storage establishments, 50 florists, 50 laboratories, 40 manufacturers of explosives, 30 army posts, 30 mineral-water bottlers, 20 bleachers and dyers, 20 glue factories, 18 photo-material manufacturers, 15 textile works, 15 soap factories, 13 electrical-instrument manufacturers, 10 sugar refineries and 5 manufacturers of ammonia.

Besides, numerous refrigerating installations are used in mercerizing works, silk and woolen mills, in the manufacture of perfumery, celluloid, isinglass, flavoring extracts, candles, glass, acetylene gas, vinegar, wine, snuff, tobacco, leather, cutlery, agricultural implements, optical instruments, temperature-measuring instruments, liquid air, etc.; for shaft sinking and tunneling; for recovery of alcohol and ethers; for prolonging animal hibernation; for retarding plant growth; for cooling air in hotels, restaurants, stores, factories and residences, and for numerous other uses.

The total number of refrigerating machines in actual use in the United States is estimated at about 20,000. The capital invested in construction of machinery for refrigeration is estimated at at least $50,000,000. The capital invested in industries depending wholly or largely upon the aid of the refrigerating machine is estimated at more than $1,000,000,000.

Direction of Flow in Brine Cooler

At the plant that I have charge of there are two exhaust-steam machines of the absorption type for cooling cold-storage rooms. They are of 15- and 25-ton capacity respectively. I think the coolers are piped wrong and would like to hear what some of the readers think about it. We use calcium brine, and both brine and ammonia

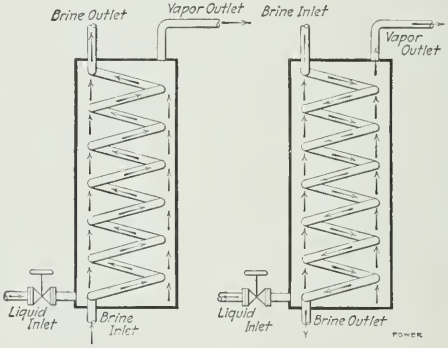


Fig. 1 Fig. 2

enter the bottom of the cooler and leave at the top. This is shown in Fig. 1. I would naturally think that the warm brine ought to enter the top where the ammonia is warm and leave at the bottom where the ammonia is the coolest, as shown in Fig. 2.

We have a great deal of trouble in making the cooler boil off enough gas to get the capacity of the machine. I think if the current of brine were changed so that it would flow in a direction opposite from the ammonia, it would give the cooler a greater capacity.

Another point that I wish to inquire about is this: We have only one circulation of brine for cooling the warehouse. We have two brine pumps, but they both pump to either cooler. Would it be better if they were piped to the separate coolers so that one pump could be used on one machine and the other pump for the other machine? When both machines are running we have a great deal of trouble dividing the work properly between them, because the brine going to each cooler cannot be divided properly.

H. E. Hooper.

Pittsfield, Mass.

EDITORIALS

Power-Plant Depreciation

A power plant uses up engines as well as coal and oil. If an engine costs twenty-thousand dollars and lasts twenty years, the plant has used up, on an average, one thousand dollars worth of engines a year, and this must be taken into account in making up the cost of power just as certainly as the cost of the coal, labor, repairs, etc., for which money is actually paid out each year.

It is usual to charge the plant with a certain percentage of "depreciation," diminution of value used-up-itiveness each year. A common figure is five per cent., which assumes that the plant would need to be entirely renewed in twenty years.

Charles M. Ripley has collected some data bearing upon the life of plants in and about New York. He furnishes a list of plants of which one has been running thirty years; two, twenty-nine years; two, twenty-five years; two, twenty-three years; five, twenty-two years; two, twenty-one years; one, twenty years; six, nineteen years, etc. An increasing number can naturally be found for the shorter ages. Most of the plants enumerated were put in by Pattison Brothers, a firm of consulting engineers, with which Mr. Ripley is identified.

The significant point is that these plants, even the oldest of them, are running along nicely, and there seems to be no good reason why any or all of them may not be in active and efficient service after a number of more years of use.

Any attempt to boost depreciation above five per cent. in an effort to show high cost of production is not justified for a plant which will have ordinarily good care.

The Smoke Evil

Experts figure that Pittsburgh's yearly soot emissions would make a pile one hundred feet in diameter and six hundred feet high or larger than the Washington monument. The money waste and damage are estimated at twelve million dollars yearly. Sample tests made some time ago in Chicago of the cost of the smoke nuisance in that city showed that the smudge bill exceeded the tax bill which was about forty million dollars a year, and the cost of smoke in other cities is fully as great in proportion to the size of the city. This includes only the injury to property. Doctors will tell you that is the least damage. They will point out how the smoke gets into the throat and lungs, and injures the health, causing chronic ailments which diminish the happiness and shorten the life of those who are not responsible for the smoke evil.

The old saying is, "Much smoke much business"—and we need the business. But the progressive engineer of today will tell you that most smoke can be avoided. It indicates incomplete combustion which means waste of coal, extra expense in labor and equipment, damage to property, sickness and loss of life. Experts say business can be done as well without smoke and point out some of the uptodate plants and cities as proof that it is unnecessary to make smoke.

In many cases it is cheaper to let the boilers smoke than it is to take measures to prevent it. Then comes the question: How can it be done, and what will it cost? There are many ways to abate smoke not all of which will work in every case, but some of them at least can be made to work in every plant. And in many cases the saving in the amount of coal consumed will pay for the installation of a good system.

Using anthracite and semi-anthracite coals will reduce the amount of smoke made as they contain a lower percentage of volatile matter, but the cost per million heat units and the trouble in getting them are too great in many localities. Bituminous coal contains a higher percentage of volatile matter but as a rule costs less per million heat units and is most universally used.

The first requirement of a smokeless boiler plant is to have the boilers properly set. Ample space must be given in the furnace for complete combustion to take place before the flames come in contact with the comparatively cold boiler. The boiler must be set higher from the grates than formerly, but that requirement alone is not sufficient. When firing by hand the fireman is apt to throw in so much coal at a time that the proper amount of air cannot reach the hydrocarbons that are being driven off when the coal is first thrown in to form complete combustion and the result is smoke. Firing in small quantities alternately, first one side and then the other, will help, and provision should be made to admit air over the fire while the hydrocarbons are being driven off. Coking the coal on a coking plate in the front end and then pushing it back over the grates will prevent smoke but makes so much extra work that it is not always feasible. The dutch-oven furnace with the long combustion arch has proved successful in many cases when properly handled.

There are many so called "smoke consumers" on the market which, when applied to boilers, automatically admit a certain amount of air into the furnace over the fire while the hydrocarbons are being driven off. This usually prevents smoke but sometimes at the expense of the coal pile, as they are not always economical.

Mechanical stokers will prevent smoke and give more complete combustion if properly installed and operated. Of these there are two general types. The overfeed and the underfeed. The overfeed uses the coking arch principle, and the coal as it is slowly fed in at the front or side gradually gives off its volatile matter which is ignited as it passes over the incandescent carbon at the rear of the furnace, and is completely burned. In the underfeed type the fire is above the green coal and the air enters at the bottom where it mixes with the hydrocarbons and must pass directly through the incandescent carbon to get into the combustion chamber; consequently combustion is more nearly complete.

But with all of these improved furnaces the human element must be taken into consideration for their successful operation. The day has come when the fireman must be something more than a laborer. The most perfect smoke consumer or furnace ever made will not work satisfactory if it is not properly handled.

The fireman must understand the theory of combustion, he must know how to control the admixture of air and coal, he must know how to analyze the flue gas and how to interpet this information, and, when put in charge of a properly installed boiler plant, must understand machinery, as well as know how to meet the demands of the boilers for steam. Last but not least he must be given some incentive to operate the plant in the most economical manner, and the greatest of these inducements are good wages and respectable treatment from the employer. A good installation plus a satisfied operator means a smokeless stack and a small coal bill.

In some localities the law requires boiler plants to be operated without making smoke and these laws are being complied with to a greater or less degree. If it can be done in one place there is no reason why it cannot in any other, if the conditions are made right. It is the duty of the lawmakers to make these laws and enforce them to prevent poisoning the air and for the benefit of humanity, and, it is the duty of the plant owner to obey them by properly installing the boilers and furnaces, and compelling those in charge to properly operate them, not only because the law says so, but to receive the benefits of the heat units that are going to waste up the stack through carelessness and neglect.

We boast of big cities. Why not clean cities as well?

Power-Plant Foresight

If a power plant is ever in condition to operate efficiently it would seem it should be just after it has been completed. Then everything is new and in perfect condition. But, perhaps, after running smoothly for several years, the efficiency begins to drop. What is the reason?

Experience has shown that it is sometimes necessary to make extensive alterations in a newly constructed power plant, because of faulty design. If the chief engineer of such a plant does not recognize the necessity of remedying the defects when discovered, the plant stands to run at low efficiency.

If a new chief engineer assumes charge and discovers the necessity of alterations: the expense of making them is entered against his administration. The first year's expenses will be excessive, but later developments will probably show that the economy of the plant is greater than it ever could have been with the original layout.

Engineers are as likely to err in judgment as others. It is as disastrous not to make desirable alterations as it is to make changes which are not instrumental in producing better plant economy.

An engineer requires what might be called a sixth sense, besides the acknowledged five senses. This extra sense enables him to look into the future, and see what is going to be required in the line of future equipment. Such an engineer will be capable of designing a power plant that will not have to be remodeled a few months after it has been put into use.

To illustrate: A small Western city voted to build and operate its own electric-light plant, and a very conservative figure as a probable cost was given. No forethought was used as to the probable growth of the electrical load, and the capacity of the original installation was but slightly in excess of the initial demand. Consequently, in a few months, the equipment was overloaded and plans had to be made for enlarging the plant. Another boiler was installed, the original engine was discarded, instead of being set up as a spare unit, a larger engine put in and additional generators purchased.

Here, then, was a new plant practically rebuilt shortly after it had originally been put into service, because someone had not the foresight to anticipate the probable increase in load demand.

As a contrast, an engineer was confronted with the problem of keeping the machinery of a plant in operation while the walls and roof of a new building were being reconstructed, the old building having burned down.

Notwithstanding the worry and anxiety of operating the machinery, there was the necessity of planning the interior of the plant, so that when future installations were put in the equipment would be arranged symmetrically, and of sufficient capacity to take care of the load for years to come, by which time the apparatus would have become obsolete and inefficient.

These are typical of two kinds of engineers, the one responsible for efficient and the other wasteful power-plant operation. In one the faculty for looking ahead was highly developed, in the other such vision was totally lacking. There are many of the latter, and all too few of the former type of engineers.

Informality in Public Service Laws

"Simplicity is one of the strong features of the law. It will not require a specialist to construe the statute." In these words, James L. Clark, a member of the Indiana Public Service Commission, recently sought to make plain that commission's laws and its working plan before the Indianapolis Lawyers Club.

To many who have followed the procedure of public-service commissions, the simplicity of their laws has been an unknown quantity. As to the necessity for specialists, it would seem that their assistance was indispensable if the petitioner hoped to gain further privilege or perhaps, in a few instances, evade his responsibilities.

It has been decided, declares Mr. Clark, that the Indiana commission's proceedings shall be conducted without the usual formality of the law; in fact, that the "very purpose intended to be accomplished by the Indiana law requires the practice to be entirely void of technicalities."

There is too much unnecessary delay in the work of some of the service commissions, due in a great measure to the extremely formal and technical composition of public utility laws. Because of this, counsel are able to quibble or acrimoniously discuss their cases to the disadvantage of public service and make justice expensive at the hands of technical "experts."

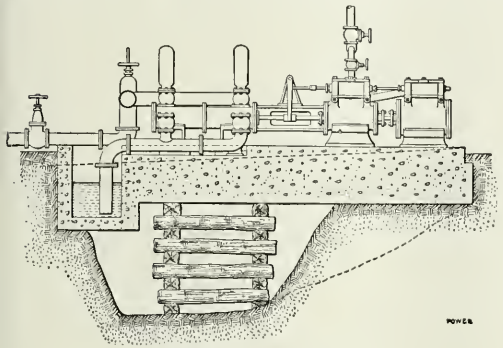
Laws must be so framed as to properly protect and develop the welfare of the state, but it is possible to accomplish the purpose of the service commission's existence and still have the law fairly free from technicalities and simple and informal in its interpretation. The work of the Indiana commission will be watched with a great deal of interest.

READERS WITH SOMETHING TO SAY

Washout under Pump Foundation

At a steel plant where two duplex compound-pressure pumps were installed the connections in the discharge line broke. The line was under 650-lb. pressure and the water washed away the soil underneath the foundation with the result that the pump settled over a foot at the water end, as indicated by the dotted line.

A gang of laborers was put to work to excavate and remove all loose soil under the foundation, and in less than a week the pump was resting on a pier of ties, the foundation and pump leveled and jacked up, and running as usual. The men had to dig down 25 ft. to reach



After the Washout

solid rock. After the ties and later two concrete piers to support the foundation were in place, and while the pump was running the ties were removed and the space filled in with concrete.

Edwin C. Miller

Lakewood, Ohio.

Fitting Crankpin under Difficulties

Some years ago I took charge of a large sawmill plant in the isolated Algoma district of Canada. Soon after the plant was started the main engine developed a startling pound. Investigation showed it to be in the crankpin, which, I discovered, projected through the crank disk and had a small pin inserted through it at right angles to the axis of the pin. I drove out this small pin and hit the crankpin a slight blow with an ordinary hammer, whereupon it fell out on the floor.

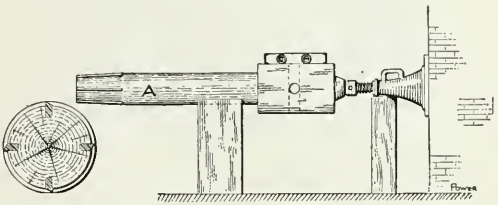
Here I was, 200 miles from the nearest machine shop and undoubtedly as far from a machine lathe. The main engine was crippled and it was the busiest part of the cutting season.

I put a liner of thin sheet iron around the pin and drove it in place. Two days later the weekly mail boat arrived and I sent a hurry order to a machine shop for a new pin, stating that we were running with a loose crankpin. Realizing that the loose pin would wear the pin bore much larger, I ordered the new pin large enough to fit the increased size of the bore.

Two weeks elapsed before the new pin arrived and with it came a letter from the shippers stating that they knew the pin bore would wear larger on account of the loose pin and they had made the new pin larger than the measurements specified to allow for the wear of the bore.

Imagine the situation! The new pin would not go more than half way into the bore and filing it down was out of the question. I dared not risk waiting another two weeks for fear the disk would break.

Beyond the woods in the village was a little planing mill which I knew had a wood-turning lathe. On this



An Improvised Boring Bar

lathe I turned an oak spindle *A* with a taper the same as the taper of the pin. Cutting tools shown in the enlarged end section of *A* were made out of files and wedged securely in the spindle. A screw-jack and a block with holes for handles were used to turn and feed the spindle while enlarging the bore in the crank disk. The boring bar was kept in line with the disk by keeping it true with a try-square. On Saturday night we bored out the hole and by Sunday noon after heating the disk we drove in the pin and fastened the connecting-rod.

Many years after this experience I saw this engine and the same pin was still giving service.

E. E. Thompson.

Thessalon, Ont.

Removal of Scale by Graphite

Much has been said recently on this subject in several engineering periodicals and the writer desires to give some notes of his recent experience with graphite as a scale remover.

We have four Stirling boilers of 300 hp. each, three under pressure at all times, the other being down for cleaning or repairs. Our boilers are frequently overloaded for short periods. We use natural gas for a fuel with Kirkwood burners set in a vertical position, eight on each side of the ashpit, using an average pressure (at the burners) of 3 oz. The working steam pressure is 150 lb. gage.

The water used in the boilers is taken from the city mains and passes through an open heater where the temperature is raised to 208 deg. F. At the city pumping

station the water is taken from the river and pumped to settling tanks from which it flows by gravity through modern sand-filtering apparatus, thence through the pumps to the reservoir and lines, and during the process

Fig. 1. Boiler Scale Removed with Graphite; Note Two-Foot Rule in Center

of filtering a sufficient amount of alum solution is added for purifying purposes.

We have had analyses made of the feed water and of the scale and tried out several boiler compounds without satisfactory results. We then tried kerosene by placing a quantity in each drum after cleaning, but the results were poor.

Tri-sodium phosphate was then tried and this did not help the scale problem, but gave the scale and the interior of the boilers a very red or rusty appearance, where-

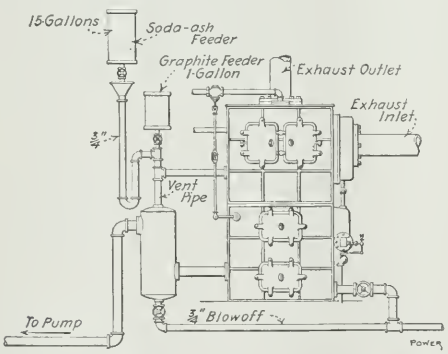


Fig. 2. Soda-Ash and Graphite Feeder Connected to Feed-Water Heater

upon the insurance inspectors reported corrosion. A small amount of soda ash is fed in with the feed water daily to neutralize the acid in the water, much of the acid coming from coal and coke works farther up the stream. Precaution must be taken here as too much soda ash will cause the boilers to foam. With boiler graphite we are getting good results at a very small cost, using only one pound per 24 hr. During this process we also tried out several mechanical cleaners as we do not believe this type of boiler can be kept clean without a good mechanical cleaner to knock out the scale after the chemicals and graphite have done their work.

In Fig. 1, compare the size of the scale to the 2-ft. rule in the center. One piece of scale was over 17 in. in length, but became broken in handling. Most of the scale is very thin; so much so that the boilers would ordinarily have been considered clean. Most of the scale was loosened and fell before the mechanical cleaner reached it, as that reached by the cleaner is pounded fine or will have marks of the cleaner on its surface. A well known make of water-turbine cleaner is used, and never before in the writer's nine years' experience in this plant did the scale come down so easily or in such large pieces as it has since using boiler graphite.

Fig. 2 shows our method of feeding the soda ash and graphite solutions to the feed water as it leaves the heater on its way to the pumps. In this way the graphite adds its lubricating qualities to the pumps.

C. E. Nigh.

Morgantown, W. Va.

The Myriawatt

As one of the authors of the original paper, "The Myriawatt," presented before the convention of the American Institute of Electrical Engineers, June, 1912, I am sending an answer with tables to Mr. Weaver's criticism of the myriawatt in Power, Sept. 9, 1913.

Mr. Weaver shows he is unaware of the purpose of the myriawatt and that he does not exactly understand just what it is. The purpose was defined in the original paper: "To introduce a new unit of power, which if adopted will afford a basis of comparison of all converters of energy, thermal and mechanical, and also will be international in its character, as it is merely a new multiple of the watt."

Mr. Weaver states that the unit has no scientific basis. Does he mean that the watt and the kilowatt have no scientific basis? If they have, why has not the myriawatt also, which is merely a decimal multiple of the watt, which means 10,000 watts? Even the boiler horsepower, confusing as it is, as now defined in the A. S. M. E. code for boiler tests, rests upon an entirely scientific basis. Mr. Weaver even finds fault with the use of "myria":

> While it is true that the word from which it is derived, means in Greek ten thousand, in English it has never had that definite meaning, but, as everyone knows, has the indefinite significance of a great number.

The following appears on page 1084 of Webster's Imperial Dictionary:

> Myriad (Gr. Myrias (ados), the number ten thousand, from myrios, countless).
>
> 1. The number of ten thousand, an aggregate of ten thousand persons or things.

While great confusion may result from the term "boiler horsepower," still it is well ingrained in American practice and about every American engineer has been accustomed to its use. The fact, as Mr. Weaver says, that the myriawatt is only 2 per cent. different in value from the

boiler horsepower, and still is based upon the same system of units as the kilowatt, recognized as the unit of engine-room output, is the main argument for the use of the myriawatt. It has all the advantages of the C. G. S. system, but still requires no effort to understand its value on the part of the engineer who has long been familiar with the boiler horsepower.

Mr. Weaver is under the impression that we intended there should be a "boiler rating based upon an engine heat consumption." He is mistaken, for we recognize that the tremendous increase during the last few years in efficiency of design and operation of boiler furnaces and prime movers has demonstrated that there can be no fixed quantitative relationship between the heat output of a boiler of a given size and the heat consumption per kilowatt of an engine. But thermodynamics teaches us that heat and mechanical energy are mutually convertible, and that a kilowatt-hour can be stated in terms of B.t.u., when the gravitational constant g is defined in value. The function of the myriawatt is to supply a power unit for the input side of a prime mover which is based upon the same system as the recognized unit of prime-mover output.

While it is true that the nominal rating of a boiler might be stated in myriawatts just as it is now occasionally expressed in boiler horsepower; nevertheless, the term myriawatt as an exact quantity means the power of ten thousands watts, or 34,150 B.t.u. per hour, based on the definition of g by Marks and Davis

$$g = 32.174 \; ft. = 9.0665 \; meters$$

To Mr. Weaver's statement:

> Again a boiler of 100 myriawatts actual on a basis of natural draft and anthracite coal for fuel would say, increase to 125 myriawatts actual with good soft coal, to 150 myriawatts actual with high chimney draft and to 200, 300 or more myriawatts actual.

I quote from the original paper: "With modern plants, notably those in marine service, operating at from two to five times this rating" (10 sq.ft. boiler surface = 1 boiler horsepower). We recognize that there is at present only a remote relationship between the actual output of a boiler and the nominal rating based upon heating surface. Even with stationary boilers, 400 per cent. nominal rating has been obtained. One speaks of a certain turbine as a 10,000-kw. machine and yet its output is almost never exactly 10,000 kw. Thus the actual output of a boiler may or may not correspond to its nominal rating. It may be as well to standardize once and for all the trade rating of boilers on the basis of square feet of heating surface, but that is entirely aside from the question of stating the thermal performance of a boiler in terms of a multiple of the recognized unit of prime-mover output.

Mr. Weaver, in a long letter to the *Electrical World*, completely riddled the boiler horsepower; but he left no adequate substitute. Let him search the universe for a better one which will be more simple and more clear of meaning than the myriawatt.

CONVERSION TABLES FOR THE MYRIAWATT

1 foot-pound	= 0 0012861 B.t.u.
1 kilogram-meter	= 0 009302 B.t.u.
1 gram-calorie	= 0 0039683 B.t.u.
1 horsepower	= 2,547 B.t.u. per hr.
1 cheval a vapeur	= 2,512 B.t.u. per hr.
1 pferde-kraft	= 2,512 B.t.u. per hr.
1 poncelet	= 3,349 B.t.u. per hr.
1 kilowatt	= 3,415 B.t.u. per hr.
1 boiler-horsepower	= 33,479 B.t.u. per hr.
1 myriawatt	= 34,150 B.t.u. per hr.

REDUCTION OF THE MYRIAWATT TO THE ABOVE UNITS

1 mw. = 34,150 B.t.u. per hr.
1 mw. = 8,605,000 gram-calories per hr.
1 mw. = 26,552,000 foot-pounds per hr.
1 mw. = 3,670,900 kilogram-meters per hr.
1 mw. = 13.410 horsepower
1 mw. = 13.597 cheval a vapeur
1 mw. = 13.597 pferde-kraft
1 mw. = 10.197 poncelets
1 mw. = 10 kilowatts
1 mw. = 1.020 boiler-horsepower

REDUCTION OF THE ABOVE UNITS TO MYRIAWATTS OR MYRIAWATT-HR.

1 B.t.u.	$= 2.928 \times 10^{-5}$ mw.-hr.
1 gram-calorie	$= 1.1621 \times 10^{-7}$ mw.-hr.
1 foot-pound	$= 3.7662 \times 10^{-8}$ mw.-hr.
1 kilogram-meter	$= 2.7238 \times 10^{-7}$ mw.-hr.
1 horsepower	$= 7.457 \times 10^{-2}$ mw.-hr.
1 cheval a vapeur	$= 7.354 \times 10^{-2}$ mw.-hr.
1 pferde-kraft	$= 7.354 \times 10^{-2}$ mw.-hr.
1 poocelet	$= 9.807 \times 10^{-2}$ mw.-hr.
1 kilowatt	$= 1\ 00000 \times 10^{-1}$ mw.-hr.
1 boiler-horsepower	$= 9\ 804 \times 10^{-1}$ mw.-hr.

The value of g is assumed to be that at sea level and 45 degree latitude = 9.80665 meters = 32.174 ft.

REDUCTION OF THE ABOVE UNITS TO GRAM-CALORIES

1 B.t.u.	$= 2.5200 \times 10^{2}$ gr. calories
1 foot-pound	= 0 3241 gr. calories
1 kilogram-meter	= 2 3442 gr. calories
1 kilogram-calorie	= 100 0000 gr. calories
1 horsepower	$= 6.417 \times 10^{6}$ gr. calories per hr.
1 cheval a vapeur	$= 6.329 \times 10^{6}$ gr. calories per hr.
1 pferde-kraft	$= 6.329 \times 10^{6}$ gr. calories per hr.
1 kilowatt	$= 8.605 \times 10^{6}$ gr. calories per hr.
1 boiler-horsepower	$= 8.4367 \times 10^{6}$ gr. calories per hr.
1 myriawatt.....	$= 8.605 \times 10^{10}$ gr. calories per hr.

HAYLETT O'NEILL.

New York City.

Abandoning Boiler in Case of Fire

To abandon a boiler in the face of a fire requires previous consideration, just as much as any of the other problems which are continually confronting the engineer of today.

If the burning building is small and composed of light material, as is frequently found in the warm climates, there is a pretty good chance of the building burning down from over the boiler without the latter being wrecked. Under this condition I would advise speeding up the feed pump sufficient to keep the boiler full of water when the safety valve opens.

On the other hand, if the burning building is large, the intense heat will certainly cause the boiler to be ruptured, so the engineer's duty, obviously, is to protect lives and property, even to the loss of his own. The energy which produces such disastrous results when a boiler explodes is stored in the hot water in the boiler. It would seem that the best thing to do would be to open the blowoff cock, and shut down the feed pump, thereby relieving the boiler of as much of its energy as possible before the explosion occurs.

J. M. ROW.

Fort McDowell, Calif.

Increased Face of Flywheel

In a plant where I was employed recently they had a 12x12-in. engine running 300 r.p.m. The flywheel was 5 ft. in diameter and formerly had a 10-in. face, but upon installing a new belt-driven dynamo of larger size a 14-in. belt was necessary, so it was a case of get a new flywheel or make the old one wider. The following method was used. A hard maple rim, 2 in. wide and of the same thickness as the flywheel rim, was made for each side of the wheel. The rim was made up of eight segments. After drilling and tapping out holes in the rim of the flywheel, the wooden rims were fastened to the flywheel

with ⅝-in. capscrews. After being securely fastened a tool rest was fixed, the engine started and the wooden rim turned off flush with the flywheel rim. The engine has been running successfully and the rim is as good as the day it was put on.

P. E. Flock.

East St. Louis, Ill.

Condenser-Tube Corrosion

In view of the fact that the corrosion and length of life of condenser tubes have been attributed to a great variety of causes, the article in Power for Oct. 14, pp. 531-533, which describes results of experiments conducted by the New York Edison Co., is welcome and interesting. There is, perhaps, no other power-plant problem that is as baffling of solution as the real cause of the erratic action of condenser tubes in actual operation.

This erratic action is observed in nearly every location where surface condensers are used, but the problem of explaining the causes for the action and the expenses due to experimenting and for replacing tubes is greatest in the large central stations usually located on the water fronts or river banks of the cities they serve. Consequently, the circulating water supplied the condensers is high in impurities, owing to the sewage and acids which find their way into the river.

Sewage usually contains more or less ammonia which is destructive to copper and its alloys of which condenser tubes are made. Ammonia is so soluble in water and the ammonia of water used in the usual sewage systems so great, and the streams into which the sewage is discharged usually so large, that it would seem as though the ammonia would be of such low concentration as to be harmless as a corroding agent. In cities like New York, however, where the population is dense, the water at times is highly polluted, as when the velocity of flow of the incoming tide is equal to that of the stream and there is no perceptible current. It would be interesting and valuable to read a discussion on the subject of sewage and trade wastes in circulating water as they affect condenser tubes.

Attributing the cause of pitting of condenser tubes to improper mill treatment, drawing and annealing, is the most logical argument yet advanced. One is convinced of the truth of this conclusion when studies of the microstructure of the tubes are made and considered in conjunction with the behavior of the tubes in actual service.

For example, it will sometimes be observed that of a lot of tubes of the same composition put in service at one time, some will corrode away in a few months, while others last as long as four years.

A case is recalled where two newly tubed condensers (all tubes of identical composition) were put in service at the same time, both operating under similar conditions of load, water, etc. After about four months' run the head was taken off one shell and the upper bank of tubes found so badly corroded that they were renewed, while the lower banks were unaffected. This started investigation which resulted in conclusions that were soon abandoned because examination of the other condenser showed the reverse condition, i.e., the top tubes were sound while the lower ones were seriously affected.

That local galvanic action set up between the constituents of the alloy and not electrolytic action of stray outside currents, causes tube deterioration is undoubtedly true. As an example of how firmly the former theory was believed in, the writer recalls one plant where a motor-generator set was installed to send current through the condensers in an opposite direction to that of the stray currents. It was always a question whether the current from the generator was assisting or opposing the electrolytic action.

Much interest has been shown in a report by Doctor Bengough on the corrosion of condenser tubes to the Corrosion Committee of the Institute of Metals of Great Britain.

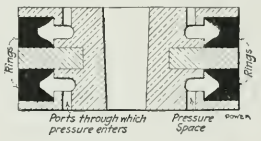
Doctor Bengough endeavored to show that pitting of tubes goes on more rapidly at high temperatures, say, 104 deg. F. and up, than at temperatures corresponding to high vacuum. Experience with the erratic action of tubes in condensers under 28 to 29.3 in. vacuum continuously during operation leads me to place little confidence in this theory. Discussion of this theory would, however, be appreciated.

B. H. Chester.

New York City.

Piston Rings Wear Cylinder

In reference to R. E. Skon's letter in the issue of Aug. 26 last, I have seen illustrations of devices to prevent the steam packing of pistons which is regarded as being undesirable, due to the excessive friction set up, causing rapid wear both of the piston and liner. I have a water piston fitted with flexible rings which rely on the pressure (160 lb. in our case) entering through four ⅛-in.



Section of Piston

ports to keep them tight against the cylinder walls and these rings wear rapidly. I have plugged up two of the ports, but it appears to make no difference and the quality of the rings is the best the makers supply. The pump is in good condition, being practically new. Can anyone offer suggestions to increase the life of these rings? A section of the piston is shown herewith.

A. M. Robb.

London, Eng.

Analysis of Mr. Chandler's Diagrams

The rise in the expansion curve was due to steam leaking into the cylinder from the receiver, due to the exhaust valve lifting off its seat when the pressure in the cylinder became less than that in the receiver.

The drop below the atmospheric line was due to a drop in the receiver pressure caused by the low-pressure cylinder drawing upon it while very little steam had been supplied to the receiver from the high-pressure cylinder during the previous stroke.

Frank P. Stoddart.

Burlington, Iowa.

[Similar replies were received from Harry D. Everett and E. H. Sawers.—Editor.]

INQUIRIES OF GENERAL INTEREST

Foot-Valve Action—Does a foot-valve on the suction pipe of a single-cylinder, double-acting water pump open and close while the pump is discharging water?

J. W. D.

At ordinary speeds of pumping and size of foot-valve, the valve on the suction pipe does not have sufficient time to close between strokes.

Plate Crushing Strength—What is meant by the "crushing strength" of a plate, in reference to figuring the bursting strength of a boiler?

J. W. D.

It refers to the resistance offered by the plate in resisting the compressive strain which exists on the edge of the plate behind a rivet, due to pulling the plate against the side of the rivet.

Injector Peculiarity—Why does high pressure sometimes cause an injector to refuse to lift water?

J. P.

Injectors for lifting water are made with a double system of tubing, viz., one for lifting and the other for forcing. The forcing system alone will do some lifting, but if too much steam is used, or enough used for forcing against high pressure, the suction becomes overheated and breaks by steam taking the place of the column of water to be lifted.

Power of Three-Phase Motor—On the "Inquiries" page of Oct. 14 issue, the statement appeared that the power of a three-phase motor is

$$\text{Kw.} = \frac{\text{Current} \times \text{voltage} \times 1.73 \times \text{power factor}}{1000}$$

This is correct for the input, but for the output it must be multiplied by the efficiency of the motor. The formula then becomes

$$\text{Kw.} = \frac{\text{Current} \times \text{voltage} \times 1.73 \times \text{power factor} \times \text{efficiency}}{1000}$$

Steam Consumption Corrected for Moisture—If the steam consumption of an engine is 28 lb. per i.hp., and the steam contains 2½ per cent. of moisture, how is the correction for consumption of dry steam made?

B. E. D.

If steam contains 2½ per cent. moisture, deduct 2½ per cent. from the actual consumption. For instance, if the actual consumption of the engine is 28 lb. of steam containing 2½ per cent. moisture, then the consumption of dry steam would be 28 — (2½ per cent. of 28) = 27.3 lb. This is the usual method of allowing for moisture in engine performances, although the presence of moisture is usually more detrimental to economy than thus accounted for.

Stack Height and Chimney Draft—Why is a boiler-furnace draft increased when the height of the stack is increased? What is the principle involved?

J. W. D.

The heated gases of a chimney rise because they have less weight or density than the atmosphere. The higher the column the greater its buoyancy or tendency to rise because the atmosphere pressing into the draft doors of the furnace is resisted by a column of less weight (gases and atmosphere) the higher the column of chimney gas extends up into the atmosphere. The effective pressure is that due to the difference between the weight of the heated gases in the chimney and a column of the external air of equal height and cross-section.

Engine Steam Consumption—Where a condenser cannot be used, how may the steam consumption of an engine be determined? Is it necessary in connection with this test to test the boiler for efficiency and weigh coal, water, etc.?

B. E. D.

The water consumption could be measured by weighing as it is fed into the boiler, if the latter supplied steam to only the engine, beginning and ending the test with the same steam pressure and same level of water in the boiler and accounting for any leaks or use of steam for other purposes. Steam consumption of engines is usually rated on a basis of dry saturated steam at some particular pressure. If only the engine economy is involved, then only the amount of water fed to the boiler and used by the engine would have to be taken into account; but if boiler efficiency is involved, the coal would have to be weighed.

Boiler Steaming Characteristics—Some claim a boiler steams better when the water is carried high; that if 2½ gages are carried less coal will be consumed than with 1½ gages. Is there any difference in coal consumption if the same amount of water is evaporated in both cases?

J. W. D.

A larger body of water carried in a return-tubular boiler may be accompanied by more uniform circulation and result in absorption of more heat of the furnace otherwise going to waste in chimney gases, thereby requiring combustion of more coal for a given evaporation.

For a given rate and system of firing, the larger the body of water the more uniform will be the pressure at which steam is generated, and for a variable rate of steam demand the larger the volume of water carried at a given temperature the larger the storage of heat and consequently the combustion can be regulated to the better advantage of the furnace economy than where the firing has to be adapted to the variable demands for steam.

Temperature Test Measurements—In a test, to take the temperature of the feed water before entering the weighing barrels, may an ordinary thermometer be used? Should the steam temperature at the throttle be obtained by steam gage or thermometer? Should the moisture in the steam at the throttle be obtained by fastening a calorimeter there?

B. E. D.

The feed-water temperature should be measured by a standard feed-water thermometer, which consists of a special thermometer dipped into a well in a brass screw plug, the well containing cylinder oil or mercury and the plug being screwed into the feed pipe so as to receive the full temperature of the feed water. The moisture is determined by a calorimeter attached where the quality of the steam is to be obtained. If the steam shows any moisture (which is probable unless a superheater is employed) there is no object in obtaining the temperature except from the pressure as shown by an accurate steam gage and tables of the properties of steam. Superheat thermometers are made and applied in the same manner as feed-water thermometers.

Latent Heat at Different Pressures—Why is there more latent heat in steam at 212 deg. F. than at 200 deg. i.e., why does the latent heat decrease as the pressure increases?

J. W. D.

A pound of water at 200 deg. F. passes into vapor by the addition of 977.8 heat units if the pressure is not in excess of 11.52 lb. per sq.in. abs. If the pressure is increased to 14.7 lb. abs., or atmospheric pressure, the water will not vaporize until its temperature has been raised to 212 deg. F. and in addition thereto, it has received 970.4 heat units. In the first instance the heat contained in the water above 32 deg. F. is 167.94 heat units and the additional heat required for vaporization being 977.8 heat units, the total above 32 deg. F. required for vaporization is

$$167.94 + 977.8 = 1145.74 \text{ B.t.u.}$$

commonly quoted as 1145.8 heat units. In the second instance the heat contained in the water above 32 deg. F. is 180 heat units; but with this amount of heat already present only 970.4 additional heat units are required for vaporization to make up the total of 1150.4. Why this is so cannot be stated. We only know from observation that temperature and pressure may be increased by addition of heat and that as temperature and pressure are thus increased the amount of latent heat required for vaporization decreases. It is a law of nature, the reason for which is inscrutable.

ENGINEERS' STUDY COURSE

Feed-Water Treatment—IV

Collecting Sample

Care must be exercised when collecting the sample to be analyzed. If the water is in an agitated condition a clean bottle or jar can be dipped into the tank or reservoir at almost any point and filled in the ordinary way. If it is more convenient to tap the supply main, a good arrangement is to allow a small stream of water to run into a clean barrel or tub continuously and dip the sample therefrom. The main thing is be sure that the bottle to contain the sample and the barrel or tub, if any is employed, are clean, and will not pollute the water with foreign matter which it does not contain naturally. A sample of from 2 qt. to 1 gal. is sufficient.

Test for Alkalinity

The first step of the analysis is to test whether the water is alkaline or acidulous in nature. Usually it is alkaline, but sometimes, when the water comes from boggy land, it may be slightly acid in character.

To test for alkalinity fill the 200-c.c. measuring flask, first seeing that it is thoroughly clean, with the test water, so that the level is exactly at the line which will be found around the neck of the flask. Empty this water into the clean 22-oz. basin and rinse the flask with distilled water, putting the rinsings into the basin also.

Distilled water may be purchased by the bottle, or if much is to be used, a home-made or purchased still may be found more economical.

Add to the 200 c.c. of test water in the basin two drops of the concentrated solution of methyl orange. Next, put into the burette some of the one-fifth normal standardized solution of hydrochloric acid and read the level at which the acid stands with great care and as accurately as possible. Now, titrate by opening the cock of the burette a small amount, allowing some of the acid to fall into the basin of test water drop by drop, stirring the water all the while with the glass rod, until the color of the water changes from canary yellow to orange and, finally, to faint pink. Shut off the acid at this point and again read the level in the burette as closely as possible. When reading the burette take as the level of the liquid the bottom of the slight curve which the surface of the liquid assumes due to the narrowness of the tube.

The analysis of a water sample is usually expressed in parts by weight of impurities per 100,000 parts of water. Thus, when a water is said to contain 20 parts of calcium carbonate what is really meant is that every 100,000 lb. of water contains 20 lb. of this compound.

Temporary Hardness

The test with hydrochloric acid as described above indicates the temporary hardness of the water and this is assumed to be caused by the presence of calcium carbonate in the water. To estimate the parts of calcium carbonate per 100,000 multiply the number of cubic centimeters of acid required by 5.

To illustrate, if it took 4.1 c.c. of the one-fifth normal standardized acid solution to neutralize a 200-c.c. sample of water the parts of calcium carbonate per 100,000 parts of water would be taken as

$$4.1 \times 5 = 20.5$$

Test for Acidity

If the water to be examined is acidulous the following method must be employed:

Carefully measure out as before 200 c.c. of the water to be tested and add two drops of the phenol-phthalein instead of the methyl orange. Load the burette with the one-fifth normal standardized solution of sodium carbonate and titrate as before, reading off as accurately as possible the number of cubic centimeters required to change the color of the water to a purple-red tint. The number of cubic centimeters thus required is then multiplied by the factor 5 to give the alkali equivalent of the acid present in the water. Thus, if 1.3 c.c. of the sodium carbonate was used in titrating the water contained acid equivalent to a sodium carbonate content of

$$1.3 \times 5 = 6.5 \textit{ parts}$$

per 100,000.

Permanent Hardness

The permanent hardness or hardness due to the sulphates is ascertained by the following test:

Filter a little more than 100 c.c. of the water to be tested and then measure exactly 100 c.c. into a clean vessel and add from the burette exactly 25 c.c. of the standardized sodium-carbonate solution. Evaporate this mixture to dryness in a porcelain dish on the water bath. Next, pour into the dish about 100 c.c. of distilled water, heat gently and stir to insure complete solution of the soluble solid matter in the dish. Next, filter the solution carefully and wash the filter well by pouring warm distilled water into it after the solution has passed through. Collect the filtered solution and the filter washings in the large porcelain basin, add two drops of methyl orange, titrate with the one-fifth normal standardized hydrochloric acid and read carefully the number of cubic centimeters required to cause the change from canary yellow to faint pink. The number of cubic centimeters of the acid solution required to bring about the color change is subtracted from 25 and the result multiplied by 5 to give the degrees of permanent hardness, expressed in their equivalent of parts of calcium carbonate per 100,000 parts of water.

Estimating Treatment

It is stated by reliable authorities that water which contains more than 20 parts per 100,000 of impurities, causing permanent and temporary hardness, should be treated before use. Whether the treatment should be made before the water is fed to the boiler is largely a matter of size of plant or amount of water used.

The quantity of lime required to treat water for temporary hardness (calcium and magnesium carbonates) may be estimated as follows: Pounds of fresh baked lime required per 1000 gal. of water equals number of parts of calcium carbonate in 100,000 (as shown by test for temporary hardness) multiplied by 0.0467.

The pounds of slaked lime required per 1000 gal. of water equals the number of parts of calcium carbonate multiplied by 0.0617.

And the pounds of caustic soda (sodium hydrate) required per 1000 gal. of water equals the number of parts of calcium carbonate multiplied by 0.0667.

Treatment for Sulphates

When lime is used for treating the carbonates the quantity of sodium carbonate or soda ash required to correct the permanent hardness may be estimated as follows: Pounds of soda ash required per 1000 gal. of water equals number of parts solid matter causing permanent hardness, multiplied by 0.0884.

When caustic soda is used for the carbonates not so much soda ash is required for the sulphates for the reason that the caustic soda and the carbonates react chemically to produce sodium carbonate (soda ash) which becomes available to react with the sulphates to produce sodium sulphate and calcium and magnesium carbonates (the latter being insoluble).

To estimate the quantity of soda ash required for the sulphates in such a case, proceed as usual to estimate the quantity required as though lime were to be used for the carbonates. Then, subtract from the quantity thus found, $^{106}/_{80}$ times the quantity of caustic soda used for the carbonates.

The foregoing materials for treating water are never 100 per cent. pure when bought in bulk and, consequently, it is necessary to allow for this when making up a treatment. The first step is to find out from the dealer what the percentage of purity is, then divide this percentage into the quantity actually required as estimated above and multiply the result by 100.

Testing Treated Water

It is well to test the treated water occasionally to make sure that the treatment is correctly proportioned. For this purpose the following additional material is needed: About a liter of standardized alcoholic soap solution of such strength that when employing a 200-c.c. sample of water, 1 c.c. of the solution will be equivalent to five parts of calcium carbonate per 100,000 parts of water, also about 2 oz. of a weak solution of silver nitrate.

The test is conducted as follows:

Partly fill an ordinary drinking glass with some of the treated water which it is desired to test. Into this put a few drops of the silver nitrate solution and note whether a snowy precipitate is formed or a brownish color is given to the water. The snowy precipitate is caused by the presence of carbonates and indicates that the quantity of lime should be increased. The brown color indicates an excess of lime.

Next draw a fresh sample of exactly 200 c.c. and pour it into a clean bottle of such size that the sample will not more than half fill it. Put some of the soap solution into the burette and read the quantity as accurately as possible. Next, run a small quantity of the solution into the bottle containing the test sample, shake the bottle vigorously for a minute or two and note whether a lather is formed. Continue to add soap solution and shake until a lather is formed which will cover the whole surface of the water when the bottle is lying on its side and remain for five minutes. When this point is reached, read on the burette scale the number of cubic centimeters of soap solution that was used. This number multiplied by 5 roughly indicates the total hardness in equivalent parts of calcium carbonate per 100,000 parts of water.

Finally, measure out another fresh sample, exactly 200 c.c. in quantity, and put this into the 22-oz. porcelain dish. Then, add to the sample two drops of methyl orange and two or three drops of the phenolphthalein. Titrate with the standardized hydrochloric-acid solution and note the number of cubic centimeters of the solution required to change the red color of the sample to a yellow shade. Then, run in more of the acid solution and read off the quantity required to turn the yellow to pink. The first reading multiplied by 10 gives the causticity, while the total cubic centimeters of the acid solution used, multiplied by 5, gives the alkalinity.

If the total hardness, as shown by the soap test, is greater than the alkalinity, it indicates insufficient proportion of soda ash in the treatment. If the total hardness is less than the alkalinity it indicates a too great proportion of soda ash. If the alkalinity is greater than the causticity it indicates an insufficient proportion of lime. If the causticity is greater than the alkalinity it indicates an excess of lime.

The method of estimating from the results obtained from the foregoing tests, what changes to make in the quantities of lime and soda ash, is exactly the same as that employed in making up the original quantities. To illustrate, if the alkalinity is greater than causticity by 1.5 c.c. of acid or

$$1.5 \times 5 = 7.5 \textit{ parts per } 100{,}000$$

the weight of the lime supplied per 1000 gal. of water should be increased by

$$7.5 \times 0.0467 = 0.35 \textit{ lb.}$$

If it should happen that the causticity was greater than the alkalinity by 1.5 c.c., or 7.5 parts per 100,000, then the weight of the lime supplied should be decreased by 0.35 lb. per 1000 gal. of water treated.

Other Scale Remedies

In addition to the staple chemicals dealt with in this series many other chemicals or preparations have been suggested and tried as scale preventives. Even such ordinary products as potatoes, tanbark, molasses, etc., have had their supporters. In addition, are the many proprietary preparations which have been placed on the market.

Kent's "Mechanical Engineers' Pocketbook" states:

"In cases where water containing large amounts of total solid residue is necessarily used, a heavy petroleum oil, free from tar or wax, which is not acted upon by acids or alkalies, not having sufficient wax in it to cause saponification, and which has a vaporizing point at nearly 600 deg. F., will give the best results in preventing boiler scale. Its action is to form a thin, greasy film over the boiler linings, protecting them largely from the action of acids in the water and greasing the sediment which is formed, thus preventing the formation of scale and keeping the solid residue from the evaporation of the water in such a plastic suspended condition that it can be easily

ected from the boiler by the process of 'blowing off.' the water is not blown off sufficiently often this sedi- ent forms into a 'putty' that will necessitate cleaning e boilers. Any boiler using bad water should be blown f every 12 hr."

At one time kerosene oil was used somewhat extensive-, its action being similar to that of the heavy petroleum l mentioned in the foregoing paragraph. But the fre- ency of accidents due to carrying an open flame into ilers in which kerosene had been used caused its use be largely abandoned.

Recently, graphite has been brought into prominence a scale preventive and many engineers will testify that has produced beneficial results. Its action is mechani- l rather than chemical. Fed into the boiler with the ater at regular intervals and in stated quantities, it nds to form a coating on the heating surface of the iler which prevents the scale from adhering. The raphite also intermixes with the crystals of the scale- rming impurities and prevents them from cementing lidly together so that they exist only as a sludge or rm of mud which can easily be blown out.

This series of articles on feed-water treatment has of ecessity dealt with only the most common of the trouble- me impurities encountered in water. Water from some ctions contains many other impurities which have not en discussed here because of the difficulty of the an- ysis necessary to detect them. Some of these cause tting and corrosion and are really dangerous when neg- cted. In some cases the nature of the water may be ch that unless the treatment is very carefully planned d executed the effects produced may be as bad as, or rse than, the effects of the original water.

Taken as a whole the subject of water analysis and eatment is really so complex as to require the study of ained chemical experts. Trying to diagnose and cure ed-water troubles by home methods and remedies is uch like trying to diagnose and cure human ills by me treatment. It works well enough when the trouble simple and slight but in the long run it is often safest d cheapest to consult a good specialist who knows what look for and how to prescribe and apply the remedy.

⁂

Ashes as Fuel

Maschinenbau, under the above title, publishes an arti- e which does not deal with a nostrum like the cobbler's ixture, which raised such a commotion some years ago, t points out that the amount of carbon in the ash taken om a boiler is rarely less than 10 to 20 per cent., and frequently much more, especially in cases of forced ring. This means a loss of something like 4,000,000 ns of coal wasted per year in the German industries. process for saving this is proposed, wherein the ashes e placed in a liquid having a specific gravity greater an that of the coal, but less than that of the ashes, so at the ashes sink to the bottom and the coal floats, both ing continuously removed. In a trial of the apparatus 00 tons of coked coal were recovered from 2000 tons ashpit waste. Of this some 500 tons were in pieces from one-quarter of an inch to nearly 2 in. in size, hile the rest was available for briquetting. The soot rried over to the tubes and back connection is some 60 r cent. carbon and the New York Edison Co. is in- stigating the practicability of briquetting it.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

The enlightenment of China has been further advanced by the recent installation of 32 electric-lighting plants. To a population of over 400,000,000, thirty-two plants is only a gleam of hope, but it's also a beginning.

⁂

Mr. Rockefeller distributed glittering Lincoln pennies to the children attending the church services.—Daily paper.

Gol' ding it, John, one of these fine days you'll go broke if you strew your wealth about so promiscus. Ye ain't goin' to riz th' price of ile on us, be ye?

⁂

Too many wage checks are being cashed in saloons, complains an industrialist. Well, pay us in cash, and we'll undertake a more lavish distribution of our wealth.

⁂

We should worry if here and now we did not acknowledge our gratitude to City Engineer Richard Smedberg, Stockholm, Sweden, for a copy of his bulletin, "Engelskspråkig väg- och Vattenbyggnadslitteratur." We say all when we say, "Tackor sa mycket, Bror Smedberg."

⁂

How the daily papers do slop over when a new power plant "approaches its final completion," whatever that means. Here's a case in point: "After years of gigantic toil and the expenditure of $19,000,000, this huge project, marking a new era in hydro-electrical development, is consummated. The now harnessed forces will be converted into 100,000 hp., and the natural energy, once squandered, will now whirr the wheels of industry." Some whirr! We can hear our chief say : Give this slush two lines of fact, and cut out the bunk!"

⁂

"I dunno much," said the farmer, "an' more'n half I know ain't so." This listens like some of the information we get when we ask a company official what caused the boiler explosion.

⁂

Suffered a terrible fright recently when a Denver dispatch said: "Pikes Peak has sunk 39 ft. in the last three years." It was a mistaken calculation, reports the Geological Survey. Now we won't be robbed of a favorite expression, "Pikes Peak or bust!"

⁂

Water costs so much in London that the new buildings over a certain value have adopted the artesian well, 52 already being operated. Anybody got a scheme whereby the sunshine can be bottled up and charged for?

⁂

Seems kind of peculiar that the Panama Exposition's Machinery Hall is being built of wood? Its eight acres of floor space demand over 7,500,000 ft. of lumber. Wood is cheap on the Coast, but when this quantity has been carved out, it will make quite a hole in the scenery.

⁂

In New York City, 72,000 smokers asked the Public Service Commission to allow "smokers" on the surface and elevated lines. And some young ladies riz up, bless 'em! and said: "Let the dear men smoke; it keeps them from grouching." A medico said modcrate smoking was beneficial. Looked like it was unanimous until Doc. Pease and two other old ladies made their spiel. This put a crimp in the petition, and we're still waiting, central.

⁂

We have been invited (along with a hall-full of other people) to meet His Serene Highness Albert, Prince of Monaco; to learn about "the queen of the white ants found at Lake Hopatcong," and to visit an entomological society's museum. Thanks! But— His Sereneness is not in our set; we have always been sluggish about going to the ant, white, or just plain ant, and— Well, we frankly nourish a prejudice against all "bugs," human or the garden variety.

⁂

Not long since, consolidation of industrial interests was the thing to do if the stockholders were to get theirs. Now, some of them have overdone it, and they're trying to "decentralize" their overconsolidation. Bit off more than they could chew?

Accounting System for Electric Companies

By Leroy W. Allison

SYNOPSIS—A comprehensive accounting system capable of expansion or contraction to meet the needs of the large or small electric-light and power company. This schedule is based on the system prescribed by the Public Utility Commission of New Jersey.

The value of a uniform accounting system for electric-power stations and auxiliary operations can hardly be overestimated. Present-day conditions demand a comprehensive and accurate system for estimating costs and profit, and necessitate the abolition of antiquated methods that revert to guesswork and neglect vital elements, or involve needless complications leading to uncertain results. It is also important that the system be capable of expansion or contraction as conditions require without a revision in regular form or order. Accordingly in considering such a system it is imperative that it afford accuracy in general schedules, completeness in individual classifications, and simplicity for adaptation in whole or in part.

The following is based upon a recently prescribed uniform system of accounting by the State Board of Public Utility Commissioners of New Jersey, and applies to electric-light, heat and power industries in that state. The standardization of this system for its purpose has been effected by a long period of study and investigation of numerous accounting methods employed locally and in other sections of the country, and of both individual and general application. No factor has been neglected that might tend to compose an adequate and comprehensive system; one to reasonably and consistently apply to large and small interests, and provide real value for individual application and public-commission treatment.

ASSET ACCOUNTS

(1) Fixed Capital Installed.
(2) Fixed Capital, Tangible and Intangible.
(3) Construction Work in Progress.
(4) Floating Capital
  (a) Materials and Supplies.
  (b) Current Assets.
    (c) Cash.
    (d) Bills Receivable.
    (e) Accounts Receivable.
    (f) Interest and Dividends Receivable.
    (g) Other Current Assets.
(5) Special Deposits
  (a) Coupon Special Deposits.
  (b) Other Special Deposits.
(6) Investments.
(7) Reacquired Securities.
(8) Sinking Funds.
(9) Other Special Funds.
(10) Prepayments.
(11) Suspense
  (a) Unamortized Debt Discount and Expense.
  (b) Property Abandoned.
  (c) Other Suspense.
(12) Corporate Deficit.

EXPLANATION OF ASSET ACCOUNTS

(2) Fixed Capital, Tangible and Intangible: That devoted to other than electric operations.

(3) Construction Work in Progress: Expenditures upon plant and equipment in course of construction, but not yet ready for service; upon completion of such work, the cost should be credited to this account and charged to the appropriate "Fixed Capital" or other accounts.

(4) Floating Capital, (a) Materials and Supplies: Including cost, with transportation charge, of all such acquired; the salvage value of discarded equipment, and of equipment, materials and supplies returned to store, regardless of whether to be consumed in construction or in operation, or later to be sold; inventories of materials and supplies should be taken at least annually, and any shortages or overages credited or debited to this account. (b) Current Assets: Sub-division. (c) Cash: Including such coming into the possession of the company in which there is a beneficial interest; credit this account with all cash disbursements of company; (d) Bills Receivable: Including the cost of all negotiable paper, as demand notes, drafts, etc.; (e) Accounts Receivable: Including all other than negotiables; (g) Other Current Assets: Including all such not includible under any previous account.

(5) Special Deposits, (b) Other Special Deposits: Including all moneys and bank credits deposited for other special purposes not elsewhere provided for.

(6) Investments: Cost of all properties acquired not for use in present operations, but as a means of obtaining control of other companies, as foreign corporation stocks, etc.; investments should be classified as bound, those held subject to a lien of some character, and free, those held free of all liens.

(9) Other Special Funds: Including any such owned or held in trust for specific purposes not elsewhere provided for.

(10) Prepayments: Providing for taxes, insurance, rents, etc., paid in advance of the period to which they pertain.

(11) Suspense, (c) Other Suspense: Including all debits not provided for elsewhere, and of uncertain final disposition, as expenses of preliminary surveys, plans, investigations, etc., of projects under contemplation; where any such project be later carried to completion, amounts so expended should be credited to this account, and later charged to the proper Fixed Capital account.

(12) Corporate Deficit: To show the debit balance, if any, in the "Corporate Surplus or Deficit Account."

LIABILITY ACCOUNTS

(1) Funded Debt Account.
(2) Unfunded Debt Account
  (a) Taxes Accrued.
  (b) Receiver's Certificates.
  (c) Judgments Unpaid.
  (d) Interest Accrued.
  (e) Other Accrued Liabilities.
  (f) Dividends Declared.
  (g) Bills Payable.
  (h) Advances from Other Companies.
  (i) Consumers' Deposits.
  (j) Other Accounts Payable.
  (k) Other Unfunded Debt.
(3) Permanent Reserves
  (a) Premiums on Stocks.
  (b) Other Permanent Reserves.
(4) Temporary Reserves
  (a) Contractual Reserves.
  (b) Non-Contractual Reserves
    (c) Accrued Amortization of Capital.
    (d) Unamortized Premium on Debt.
    (e) Other Required Reserves.
(5) Optional Reserves
  (a) Casualty and Insurance Reserve.
  (b) Other Optional Reserves.
(6) Capital Stock Accounts.
(7) Corporate Surplus.

EXPLANATION OF LIABILITY ACCOUNTS

(1) Funded Debt Account: To be divided into classes, such classes being determined by the four characteristics: Mortgage or other lien or security therefor; rate of interest; interest dates, and date of maturity. Account to include "Debentures," as promissory notes unsecured by mortgage or other lien, and such securities commonly known as "plain bonds."

(2) Unfunded Debt Account, (e) Other Accrued Liabilities: Including liabilities not elsewhere provided for, particularly those accruing from day to day, but not becoming due until a certain date, as interest, rent, taxes, etc.; (h) Advances from other companies: Such advances as may be received to pay for construction or additions and betterments to the plant and equipment, or for any other purpose; (j) Other Accounts Payable: Open accounts to miscellaneous creditors as not elsewhere provided for; (k) Other Unfunded Debt: Including all unfunded debt of the company not otherwise provided for by this schedule.

Permanent reserves are those that must be maintained intact during the life of the company; temporary reserves are those not intended to remain intact during the life of the company. Contractual reserves are those necessitated by contracts of the company, such as to cover sinking funds provided for in mortgages, and the like. Non-contractual reserves are those of a temporary nature, raised without being required under any contract.

(3) Permanent Reserves, (b) Other Permanent Reserves: All reserves not otherwise provided for, created to remain intact during the life of the company.

(4b) Noncontractual Reserves, (c) Accrued Amortization of Capital: Providing for the crediting of such amounts as are

charged from time to time to "Operating Expenses," or other accounts, to cover depreciation of plant and equipment, and other amortization of fixed capital. (d) Unamortized Premium on Debt: To include the excess of cash value received over the sum of par value of securities, or other evidence of indebtedness and the accrued interest. (e) Other Required Reserves: Including all reserves not elsewhere provided for.

(6) Capital Stock Accounts: To include a separate account for each class of stock issued.

(7) Corporate Surplus: To show the credit balance, if any, in the "Corporate Surplus or Deficit Account."

FIXED-CAPITAL ACCOUNTS

(1) Land Devoted to Electric Operations.
(2) Organization.
(3) Franchises.
(4) Patent Rights.
(5) Other Intangible Electric Capital.
(6) General Structures.
(7) General Equipment { (a) General Office Equipment. (b) General Shop Equipment. (c) General Store Equipment. (d) General Stable Equipment.
(8) Dams, Canals and Pipe Lines.
(9) Power Plant Buildings.
(10) Furnaces, Boilers and Accessories.
(11) Steam Engines.
(12) Turbines and Water Wheels.
(13) Gas Producers and Accessories.
(14) Gas Engines.
(15) Electric Generators.
(16) Accessory Electric Power Equipment.
(17) Miscellaneous Power Equipment.
(18) Substation Buildings.
(19) Substation Equipment.
(20) Poles and Fixtures.
(21) Underground Conduits.
(22) Transmission System.
(23) Distribution System { (a) Overhead Distribution System. (b) Edison Tube System. (c) Other Underground Distribution System.
(24) Line Transformers and Devices.
(25) Electric Services.
(26) Electric Meters.
(27) Electric Meter Installation.
(28) Municipal Street-Lighting System.
(29) Commercial Arc Lamps.
(30) Glower Lamps.
(31) Electric Motors and Heaters.
(32) Electric Tools and Implements.
(33) Electric Laboratory Equipment.
(34) Other Tangible Electric Capital.
(35) Engineering and Superintendence.
(36) Law Expenditures during Construction.
(37) Injuries during Construction.
(38) Taxes during Construction.
(39) Miscellaneous Construction Expenditures.
(40) Interest during Construction.

EXPLANATION OF FIXED-CAPITAL ACCOUNTS

(1) Land Devoted to Electric Operations: Including land occupied by generating stations and their appurtenances; rights of way for transmission and distribution lines, and other electric operations; rights of way for canal and pipe lines, water rights of pondage, flowage and submersion.

(2) Organization: Cost of organizing company, and all other costs incident thereto.

(3) Franchises: Including the amount (exclusive of any tax or annual charge) actually paid as the consideration of such franchise or franchises.

(4) Patent Rights: Including cost of all rights acquired by the company in or under valid patents granted to inventors for inventions and discoveries which are necessary to the economical conduct of the company's electric operations.

(5) Other Intangible Electric Capital: Including the cost of all other property coming within the bounds thereof and devoted to electric operations.

(6) General Structures: Embracing the cost of all buildings of a permanent nature devoted to general corporate purposes, as general office buildings, general shops, general storehouses, etc.

(7) General Equipment, (b) General Shop Equipment: To include furnaces, boilers, gas producers, engines, electric generators, and other power apparatus used for the operation of machinery in shops; machine tools, cranes, hoists, shafting, belts and other shop equipment.

(8) Dams, Canals and Pipe Lines: Including the cost of all such devoted to the utilization of water power and delivery of the water to the headgate of turbine or water wheel; all wasteways from the outlet of draft-tube to the point of final discharge; gates, valves and other accessories.

(16) Accessory Electric Power Equipment: Including the cost of all electric equipment not included in other accounts, as busbars, regulators, station switchboards and equipment, circuit-breakers, switches, ammeters, voltmeters, wattmeters, and the like; also, headgate motors, pump motors, air-compressor motors, etc., and special high-tension transmission equipment at power stations.

(17) Miscellaneous Power Equipment: To include the cost of all miscellaneous equipment not included in other accounts, as belts, hangers, countershafts and other apparatus intermediary between the prime mover and the electric generator, cranes, hoists, machine tools, etc.

(19) Substation Equipment: Including the cost of all electric machinery and apparatus, and general equipment.

(22) Transmission System: To include the cost of all cables, wires, insulators and insulating material.

The transmission system is classed as that portion of the outside line or conductor system preceding the point of voltage reduction or other change, as when the electric energy generated (or received from another company) is conducted, either at the voltage of generation or at a higher voltage, to a point where it is lowered in voltage by means of step-down transformers, or changed as to kind and frequency by means of motor-generator sets, rotary converters, or frequency changers. Primary wiring, however, in lighting systems at not to exceed 4400 volts, four-wire, three-phase, is classed as a part of the distribution system; tie-lines between generating stations and substations follow a like rule. Line transformers are not included with the above-mentioned "step-down transformers."

(23) Distribution System, (a), (b) and (c): To include the cost of all distributing main conductors and feeders; all cables, wires, insulators and insulating material.

(25) Electric Services: To include the cost of all conductors and equipment used in connecting the distribution mains to render service to consumers. When consumers are required to pay all or part of cost of such service connections, only that portion of cost not chargeable to the consumer should be charged to this account; cost of renewing or modifying services is not included.

(28) Municipal Street-Lighting System: Including the cost of all property of the company specially provided for street lighting; not to include any part of general distribution system, but any particular apparatus in the utilization plant devoted to the municipal service.

(30) Glower Lamps: Including the cost of all such supplied to consumers, as well as municipal buildings, where there is an expectancy of life in service of more than one year.

(31) Electric Motors and Heaters: Including the cost of all such property, and appurtenances thereof as fans, etc., leased to consumers.

(34) Other Tangible Electric Capital: Providing for all such not otherwise included in accounts in this schedule.

(35) Engineering and Superintendence: To include all expenditures for such services on preliminary and construction work when such disbursements cannot be charged to specific construction.

(37) Injuries during Construction: Including all expenditures incident to injuries of all classes to persons when caused directly in connection with construction of electric plant and equipment.

(39) Miscellaneous Construction Expenditures to include the salaries and expenses of executive and general officers, clerks and the like, of the electric plant while under construction; also all construction and equipment items of a special and incidental nature not properly chargeable to other accounts in this schedule.

The foregoing accounts, comprising the three schedules, "Asset Accounts," "Liability Accounts" and "Fixed Capital Accounts," may be defined in general as the "balance sheet" or "indicant accounts." The balances of such at any particular time will show the current conditions of a company's affairs, so far as such conditions may be shown through accounts. These three schedules with their subsidiary classifications, represent additionally the main accounts of a company prior to its period of activity as a "going concern."

Commencing with active operation, a second schedule of accounts in which to classify the accounting history of the various changes of growth and conditions is necessitated. This schedule may be termed in general the "income account," comprising a group of accounts which being usually made up on a yearly basis and closed into one grand account of "Corporate Surplus or Deficit," ties

together both schedules, viz.: Indicant and Income Accounts.

The income account may likewise be divided into three general schedules, as: General revenue account, operating revenue account, and operating revenue deductions or operating expense account. These schedules with their general divisions and subdivisions will accordingly be considered in this regular order:

GENERAL REVENUE ACCOUNTS

- Non-Operating Revenues.
  - (1) Rents Accrued from Lease of Electric Plant.
  - (2) Miscellaneous Rent Revenues
    - (a) Leasehold Revenues.
    - (b) Other Rent Revenues.
  - (3) Interest Revenues
    - (a) Interest from Investments.
    - (b) Interest from Other Sources.
  - (4) Dividend Revenues.
  - (5) Miscellaneous Non-Operating Revenues.
  - (6) Non-Operating Revenue Deductions
    - (a) Rent Expense.
    - (b) Interest Expense.
    - (c) Dividend Expense.
    - (d) Miscellaneous Non-Operating Expense.
    - (e) Non-Operating Taxes.
    - (f) Uncollectible Non-Operating Revenues.
- Income Deductions
  - (7) Interest Accrued on Funded Debt.
  - (8) Other Interest Deductions.
  - (9) Rent for Lease of Other Electric Plant and Equipment.
  - (10) Miscellaneous Rent Deductions
    - (a) Joint Facility Rents.
    - (b) Miscellaneous Rent Deductions.
  - (11) Miscellaneous Deductions From Income
    - (a) Sinking Fund Accruals.
    - (b) Guarantee of Periodic Payments.
    - (c) Loss on Operations of Others.
    - (d) Other Contractual Deductions from Income.
  - (12) Amortization Deductions
    - (a) Amortization of Landed Capital.
    - (b) Amortization of Debt Discount and Expense.
    - (c) Amortization of Premium on Debt.
- Appropriation Accounts
  - (13) Bad Debts Collected.
  - (14) Other Additions to Surplus.
  - (15) Expenses Elsewhere Unprovided For.
  - (16) Dividends on Outstanding Stocks.
  - (17) Miscellaneous Appropriations
    - (a) Amortization Elsewhere Unprovided For.
    - (b) Appropriations to Reserve.
    - (c) Gifts to Controlled Corporations.
    - (d) Other Appropriations.
  - (18) Bad Debts Written Off.
  - (19) Other Deductions from Surplus.

EXPLANATIONS OF GENERAL REVENUE ACCOUNTS

(1) Rents Accrued from Lease of Electric Plant: To include all revenues from the company's interest in the electric plant or equipment held by others under some form or lease whereby it surrenders possession of such property.

(2) Miscellaneous Rent Revenues. (a) Leasehold Revenues: Including all revenues from any lease of term greater than one year. (b) Other Rent Revenues: Including all revenues from any lease or contract of entire term not exceeding one year, or which is held at will or upon sufferance.

(5) Miscellaneous Non-operating Revenues: To include all such accruing to the company not elsewhere provided for.

(6) Non-operating Revenue Deductions, (a) Rent Expense: To include all expense arising in connection with the procuring of revenues leased to others, as cost of negotiating contractors', collector's commissions, etc. (d) Miscellaneous Non-operating Expense: Including all such non-operating expenses not otherwise provided for. (e) Non-operating Taxes: Including all taxes accruing upon non-operating property.

(8) Other Interest Deductions: To include all interest accrued on receiver's certificates and on all interest bearing unfunded obligations of the company.

(10) Miscellaneous Rent Deductions, (a) Joint Facility Rents: To include profit or return upon any plant or equipment when such is maintained or operated by another company for the joint benefit of both companies, and under a joint arrangement for sharing the expense. (b) Miscellaneous Rent Deductions: To include all miscellaneous rents payable not otherwise provided for.

(11) Miscellaneous Deductions from Income, (c) Loss on Operations of Others: To include all liabilities accruing to the company through the terms of any contract whereby it is bound to contribute toward reimbursement of losses resulting from the operations of others. (d) Other Contractual Deductions from Income: To include all contractual liabilities not elsewhere provided for.

(12) Amortization Deductions, (a) Amortization of Landed Capital: Including such proportion of original money cost of landed capital as is necessary to cover the proportion of life thereof expired through the respective period of accounting. (b) Amortization of Debt Discount and Expense: Including that proportion of the unamortized discount and debt expense on outstanding debt applicable to the respective period.

(14) Other Additions to Surplus: Providing for the crediting of all additions to surplus because of erroneous accounting in prior fiscal periods, and all other additions not elsewhere assignable to specific accounts.

(15) Expenses Elsewhere Unprovided For: To include all expenses not chargeable to other accounts, such as fines levied on the company, donations to funds, etc.

(17) Miscellaneous Appropriations, (d) Other Appropriations: To include all optional appropriations made by the company not elsewhere provided for.

(19) Other Deductions from Surplus: Including all deductions from surplus because of erroneous accounting in prior fiscal periods, and all other deductions not otherwise provided for.

OPERATING-REVENUE ACCOUNTS

(1) Municipal Street-Lighting—Arc.
(2) Municipal Street-Lighting—Incandescent.
(3) Commercial Flat Rate Lighting.
(4) Commercial Flat Rate Power.
(5) Commercial Metered Lighting.
(6) Commercial Metered Power.
(7) Sale of Current to Railway Companies.
(8) Sale of Current to Other Electrical Companies.
(9) Rent of Electric Appliances.
(10) Electric Merchandise and Jobbing Revenue.
(11) Joint Electric Rent Revenue.
(12) Other Miscellaneous Electric Revenue.
(13) Sale of Steam.

EXPLANATION OF OPERATING-REVENUE ACCOUNTS

(8) Sale of Current to Other Electrical Companies: To include all revenues derived from the sale of electric energy to other electrical companies, to be distributed over their own lines to consumers, or portion thereof appropriated for their own benefit whether for light, heat or power.

(10) Electric Merchandise and Jobbing Revenue: Including all receipts from the sale of electric merchandise, and from electric jobbing.

(11) Joint Electric Rent Revenue: To include the profit or return upon property when a company engages in electric operations for the production of some of its product for the benefit of another or others, under an arrangement for apportioning the expense; such profit or return credited to be over and above any provision for wear and tear and depreciation of the particular plant.

(12) Other Miscellaneous Electric Revenue: To include all revenues derived from electric operations not included in any of foregoing accounts.

OPERATING-EXPENSE ACCOUNTS.

I. Production Expenses.

- (1) Station Wages
  - (a) Station Superintendence and Care.
  - (b) Boiler Labor.
  - (c) Producer Labor.
  - (d) Engine Labor.
  - (e) Electric Labor.
- (2) Fuel
  - (a) Fuel for Steam.
  - (b) Fuel for Producer Gas.
- (3) Other Station Supplies and Expenses
  - (a) Water for Steam Power and Gas.
  - (b) Water for Hydraulic Power.
  - (c) Lubricants for Power.
  - (d) Production Supplies.
  - (e) Station Expense.
- (4) Repairs to Station Buildings.
- (5) Repairs to Steam Equipment
  - (a) Boilers and Furnaces.
  - (b) Boiler Apparatus.
  - (c) Steam Accessories.
  - (d) Reciprocating Engines.
  - (e) Steam Turbines.
  - (f) Mechanical Apparatus.
- (6) Repairs to Hydraulic Equipment
  - (a) Dams, Canals and Pipe Lines.
  - (b) Turbines and Water Wheels.
- (7) Repairs to Gas Power Equipment
  - (a) Gas Producers and Accessories.
  - (b) Gas Engines.
- (8) Repairs to Electric Equipment
  - (a) Electric Generators.
  - (b) Accessory Electric Equipment.
- (9) Miscellaneous Station Repairs
  - (a) Tools and Implements.
  - (b) Miscellaneous Station Equipment.
- (10) Steam from Other Sources.
- (11) Power Gas from Other Sources.
- (12) Electric Energy from Other Sources.
- (13) Joint Production Expenses—Credit.

II.—Transmission Expenses.

- (14) Substation Wages.
- (15) Substation Supplies and Expenses.
- (16) Repairs to Substation Buildings.
- (17) Repairs to Substation Equipment.
- (18) Repairs to Transmission Lines
  - (a) Repairs to Transmission Poles and Fixtures.
  - (b) Repairs to Overhead Transmission Conductors.
  - (c) Repairs to Underground Transmission Conduits.
  - (d) Repairs to Underground Transmission Conductors.
- (19) Joint Transmission Expenses—Credit.

III.—Electric Storage Expenses.

(20) Electric Storage Expenses
- (a) Storage Battery Labor.
- (b) Storage Battery Supplies.
- (c) Storage Battery Renewals.
- (d) Repairs to Storage Battery Accessories

IV.—Distribution Expenses.

(21) Distribution Wages
- (a) Superintendence.
- (b) Miscellaneous Distribution Labor.

(22) Distribution Office Expense.

(23) Repairs to Distribution Lines
- (a) Repairs to Distribution Poles and Fixtures.
- (b) Repairs to Overhead Distribution Conductors.
- (c) Repairs to Underground Distribution Conduits
- (d) Repairs to Underground Distribution Conductors.

(24) Repairs to Electric Services.

(25) Transformer Maintenance
- (a) Setting and Removing Transformers.
- (b) Repairs to Transformers.

(26) Meter Maintenance
- (a) Setting and Removing Meters.
- (b) Meter Expense.
- (c) Repairs of Meters.

V.—Utilization Expenses.

(27) Commercial Arc Lamp Maintenance
- (a) Commercial Arc Lamp Expense.
- (b) Repairs to Commercial Arc Lamps.

(28) Commercial Incandescent Lamps.

(29) Consumers' Installation Expenses
- (a) Inspection of Consumers' Premises.
- (b) Repairs to Consumers' Installations.

(30) Municipal Street Arc Lamp Maintenance.
- (a) Municipal Street Arc Operation.
- (b) Municipal Street Arc Repairs.

(31) Municipal Street Incandescent Lamp Maintenance
- (a) Municipal Street Incandescent Operation.
- (b) Municipal Street Incandescent Repairs.

VI.—Commercial Expenses.

(32) Commercial Administration
- (a) Commercial Department Indexing.
- (b) Commercial Department Collecting.
- (c) Commercial Department Contracts.
- (d) Commercial Department Accounting.
- (e) Commercial Department Miscellaneous.

VII.—New Business Expenses.

(33) Promotion Office Expenses
- (a) Promotion Management.
- (b) Demonstrations.
- (c) Promotion Office Expense.

(34) Advertising
- (a) Advertising Salaries and Expenses.
- (b) Advertising Sundries.

(35) Canvassing and Soliciting.

(36) Promotion Wiring and Devices
- (a) Promotion Wiring.
- (b) Promotion Signs and Devices.

VIII.—General and Miscellaneous Expenses.

(37) Salaries and Expenses of General Officers.
(38) Salaries and Expenses of General Office Clerks.
(39) General Office Supplies and Expenses.
(40) General Law Expenses.
(41) Miscellaneous General Expenses.
(42) Insurance.
(43) Relief Department and Pensions.
(44) Electric Franchise Requirements.

(45) Injuries to Persons and Property
- (a) Accidents and Damages.
- (b) Law Expenses Connected with Damages.

(46) Stationery and Printing.

(47) Store and Stable (or Garage) Expenses
- (a) Store Expenses.
- (b) Stable Expenses.

(48) Miscellaneous Adjustments—Balance
- (a) Inventory Adjustments—Balance.
- (b) Discounts on Materials and Supplies.
- (c) Duplicate Electric Charges—Credit.

(49) Repairs of General Structures.
(50) General Amortization.
(51) Taxes.
(52) Uncollectible Electric Bills.

EXPLANATION OF OPERATING-EXPENSE ACCOUNTS

(3) Other Station Supplies and Expenses, (e) Station Expense: To include general and miscellaneous expenses in generating plant not specifically chargeable under other heads, such as lighting, heating and cleaning systems, fire-protection system, telephone, etc.

(5) Repairs to Steam Equipment, (f) Mechanical Apparatus: Including apparatus auxiliary to prime movers, such as condensers, packing tubes, renewing tubes, and pumps, oiling systems, etc.

(10) Miscellaneous Station Repairs, (b) Miscellaneous Station Equipment: To include particularly power transmission equipment and the like, as shafting, belting and clutches; motors, hoists, cranes, etc.

(11) Steam from Other Sources: Including the cost of all purchased or jointly produced steam consumed in the power plant of the electric department.

(13) Joint Production Expenses—Credit: Providing for the crediting of the portion of production expenses chargeable to other companies when any plant or equipment is maintained or operated by the accounting company for the joint benefit of itself and others, under an arrangement for apportioning the operating expenses. The portion so credited should not include any allowance for profit or return upon the value of the property.

(19) Joint Transmission Expenses—Credit: Providing for a similar crediting as under (13).

(22) Distribution Office Expense: To include the cost of all supplies and expenses of the office of the superintendent of the distribution department; maps, records, etc., of overhead and underground lines, cost of drawing materials, and the like.

(24) Repairs to Electric Services: To include the cost of repairing underground and overhead services leading from mains to consumers' premises.

(32) Commercial Administration, (e) Commercial Department Miscellaneous: To include all expenses incurred in selling electric power and products, and other items not included under classifications in commercial expenses or new business expenses.

(41) Miscellaneous General Expenses: Including the cost of telephone and telegraph service, and other miscellaneous expenses connected with the general management not provided for elsewhere.

(44) Electric Franchise Requirements: Including the cost of electric energy and other materials and supplies furnished to municipal corporations in compliance with franchise requirements, for which no payment is received.

(48) Miscellaneous Adjustments—Balance, (c) Duplicate Electric Charges: Providing for the crediting of all charges made to any accounts in electric operating expenses for electric energy or other product of electric operations consumed in such operations.

(50) General Amortization: To include charges to cover such wear and tear and obsolescence and inadequacy as have accrued during the period in the tangible electric capital of the company, and such portion of the life of intangible fixed capital as has expired or been consumed during the period.

(52) Uncollectible Electric Bills: Providing for the charging of amounts for electric service, etc., found impracticable of collection; upon such entry, the sum should be credited to the account receivable in which it was heretofore carried.

Absorption of Machine Vibrations

By Dr. Robert Grimshaw

In these days of "rattle and row" it is refreshing to find a society for the prevention of both—not a philanthropic association, but a business organization which has treated the problem from the technical and commercial points of view, and deliberately worked out methods and appliances for the various cases which have been presented to it, or which in the very nature of things have presented themselves.

The "Company for the Prevention of Noise and Vibration," of Berlin, has taken up this work which the increasing size and speed of machines has rendered so acute; "suiting the punishment to the crime"; using, among other methods and mediums, cork reinforced with iron, slabs of compressed woven materials, and a special material which the company has named "Silenz," for damping aërial sound waves, for use in music rooms, telephone cells, etc.

As regards the reduction of machine vibrations through the foundation; it is not enough to separate the machine (as, for instance, an unbalanced steam engine), from the surrounding walls by an air space, as the earth on which the foundation rests is elastic. So called sound-proof floors are also insufficient; as often, on account of their double construction, they act as sounding boards and increase the noise. Elastic material under the foundation does not prevent the vibrations being carried by the foundation bolts; even where the machines are not bolted down, it is in few cases sufficient to set them on cork or on similar inelastic material, as this is apt to be non-homogeneous and its elastic limit is liable to be exceeded locally; so that the very portions which carry the most weight will act inelastically and transmit the vibrations.

The methods of the company consist principally in taking up the vibrations in a construction or appliance where they are neutralized by friction. For instance, the foot

K, Fig. 1, of a machine is connected by a stud bolt S with a vibration plate P which hangs on three rods A, B, and C, the tension of which latter is so regulated by nuts that they can carry the weight of the machine. The

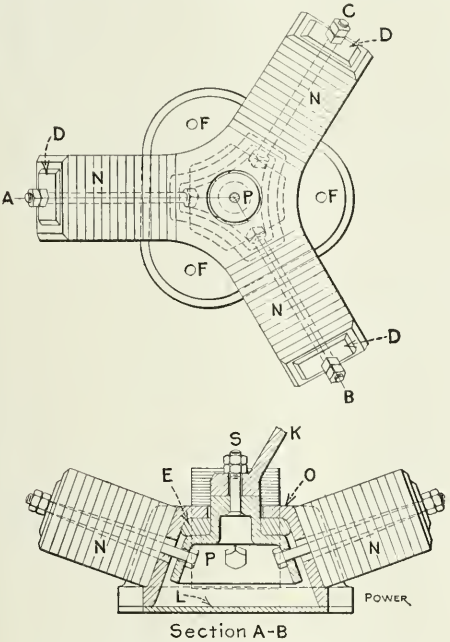


Fig. 1. Plan and Sectional Elevation Vibration-Absorbing Device

stresses in the rods are taken up by the nuts and a pressure plate D, and transmitted to a series of elastic layers N, and further to a support O, which is fastened to the foundation or floor by bolts F. Between the vibration plate P and the support O there is an elastic layer E, which damps that portion of the vibrations that exist above the center of gravity. As this portion is much

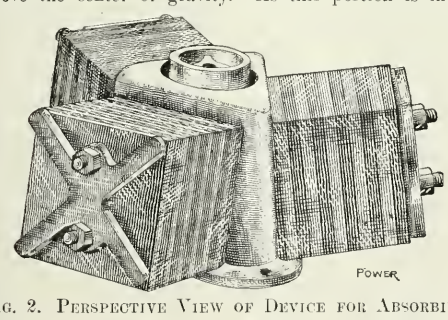


Fig. 2. Perspective View of Device for Absorbing-Machine Vibration

less than the other, this second elastic layer may be thinner than N; L is soft-metal plate.

Fig. 2 shows the construction as adapted to taking up not only vertical but also horizontal vibrations, and, consequently, compound ones, such as elliptical vibrations.

In the case of electro motors (and especially of those for rotating phase currents) it is often difficult to distinguish if the vibrations are carried by the air or by the foundation. The Siemens-Schuckert works have already supplied over 100 of their motors with quieters of the system described. In the German navy, the motor-generator transformers are similarly insulated.

Iron beams and girders are insulated by completely covering them with plates of a special material which preserves its elasticity, without getting hard under the weight resting thereon.

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Rushing Work on Panama Exposition

It has officially been announced that all of the main exhibit palaces of the Panama-Pacific International Exposition will be completed nine months before Feb. 20, 1915, the opening day; some of the buildings will be completed even earlier. This announcement, following the promise of the management made more than one year ago that the exposition would be completed nine months before the opening day and that the exhibit palaces would be built upon a definite schedule, confirms all that was said before. The preparations are further advanced today than were those of any other international exposition at a corresponding time before its formal opening; the work is proceeding upon schedule, and there will be no periods of delay or of congestion in the work. Building contracts provide bonuses for completion under the time limit.

A tremendous amount of preliminary work has been accomplished. Based upon the total amount of preparation required, the division of works estimates that today the exposition is more than two-thirds completed.

The exposition site, covering 635 acres of land near one of the most picturesque residential sections of San Francisco, was long since cleared of houses and other structures and fenced in. The underground work, completed almost throughout, included the reclamation of 7 acres of land from San Francisco Bay; the installation of a high-pressure water system for fire purposes, two-thirds completed; a low-pressure service water system, well advanced; an extensive drainage system (completed in the amusement concessions and foreign nations' district and nearing completion in the main exhibit district, where it is being carried along with the buildings themselves) and the laying of underground conduits for the electric wires for the transmission of light and power.

Ten of the huge exhibit palaces are under construction, framework of three is now rising, the flooring of practically all of the others is completed and the assembled parts are mostly ready to be raised to place. More than 70,000,000 ft. of lumber will be used in this main exhibit section, and over 25,000,000 ft. have already been delivered, with 40,000,000 ft. contracted for. Thirty-two steamers are carrying the lumber.

The streets, avenues, roads and paths are laid out, curbs are well along and a contract for the delivery of 70,000 cu.yd. of road rock, with an ample time limit, is being fulfilled.

A standard-gage railroad is being laid, the tracks being nearly all down and parts of the road in operation conveying material. A completed freight ferry slip receives car floats regularly, and a commodious harbor on the water front, with a system of wharves, daily dock steamers with lumber and other building supplies.

The Service Building, housing the staff of the division of works, is completed, even to the gardens and lawns surrounding it, and has been in use all this summer.

Of the 12 great structures in the main group of exhibit palaces, the Machinery Building is erected, roofed and floored and is now receiving its covering of imitation Travertine stone, and its cornices and pillars. The Palace of Education is floored and the frame is about half up. Framing of the Palace of Food Products has been commenced and the floors of the Palaces of Agriculture, Liberal Arts and Manufacturers are nearly completed, while those of the Palaces of Varied Industries, Transportation and Mines and Metallurgy are being laid.

The contract for the construction of the Palaces of Fine Arts has been let and those for the Palace of Horticulture and the Festival Hall will be awarded soon, all to be completed well within the time limit.

Many other lesser structures are built or being built with rapidity. As an example, the building for the Republic of Honduras, ground for which was broken Aug. 20, is nearly all in frame and its floor is being laid.

The extensive park system is advancing as rapidly as the structural work. Along the Marina, the grass for the broad esplanade is growing luxuriantly and the sites of other parks and gardens are now graded and receiving their covering of fertile soil and enriching material. The shrubbery and plans for the landscape-engineering scheme are all on hand, ready for transplanting when desired, which will begin this autumn, with the erection of the exhibit palaces.

Averaging Recording-Gage Records

By Lloyd W. Taylor

SYNOPSIS—Simple method of averaging recording-gage records, followed by explanation of method for those who wish to know the reasons why.

Frequently it is desired to obtain the average of a recording-gage record to a fair degree of accuracy. To do this without either an averaging instrument or a planimeter is practicaly impossible. Since planimeters are more common than suitable averaging instruments, it is thought that the following method might be used to advantage.

In averaging a record by this method, four things must be known: The area A in square inches inclosed by the record; the straight-line distance D from pivot to point of the recording arm; the number of scale divisions C per inch of travel of the pen point, these scale divisions being in pounds per square inch, volts, amperes, or in whatever units the gage is intended to measure; the radius R of the center circle of the chart, that is, the distance in inches from the center of the chart to the zero center of the scale.

The first quantity A is found by means of the planimeter; the remaining three are simple measurements which vary with different gages. Once taken, these measurements may be kept for reference.

Assuming that these four quantities are known, the first step will be to solve the expression $\sqrt{A} \div 3.544\ D$, and unless some mistake is made this will be less than $\frac{1}{2}$. In the accompanying table, the calculated value of $\sqrt{A} \div 3.544\ D$ is given and opposite the corresponding value of S, which appears in the following formula:

$$Av.\ reading = C\ (D\ S - R)$$

where D, C and R are the second, third and fourth known quantities respectively.

Sometimes it is desired to find the average reading for a part of a revolution of the chart. This is done by drawing a straight line from each extremity of the part of the record to be averaged to the center of the chart. Measure with a protractor, the angle which these lines make with each other. Divide 360 by the number of degrees in this angle and multiply the area inclosed by the two straight lines and the record by this quotient. Take the result equal to A and proceed as above.

For those who desire to know the reasons why the above is true, the following explanation is appended: The path of the recording pen, when the chart is stationary and pressure applied, is the arc of a circle whose radius is D. If the recording pen should remain stationary for a full revolution of the chart, a circle would be described. Call the area of this circle A. Then the length of a scale-divided arc from center to circumference of this circle is

$$2\ D\ \sin^{-1}\frac{\sqrt{A}}{2\ D\sqrt{\pi}}$$

which equals

$$D\left(2\ \sin^{-1}\frac{\sqrt{A}}{3.544\ D}\right)$$

in which the designated angle is expressed in radian measure. The expression in brackets is a generalization of the quantity S in the accompanying table.

Subtract from this arc, the radius R of the zero circle and multiply the remainder by the constant of calibration. The result is the reading at which the pen was held while the dial was revolved. For the purposes of these calculations, the area of the irregular record is taken as the area A of the averaging circle, and the average reading deduced from it.

VALUES OF S FOR USE IN FORMULA

$\frac{\sqrt{A}}{3.544\ D}$	S	$\frac{\sqrt{A}}{3.544\ D}$	S
0.01	0.0200	0.26	0.5261
0.02	0.0400	0.27	0.5468
0.03	0.0600	0.28	0.5676
0.04	0.0801	0.29	0.5884
0.05	0.1001	0.30	0.6093
0.06	0.1201	0.31	0.6303
0.07	0.1401	0.32	0.6514
0.08	0.1602	0.33	0.6726
0.09	0.1802	0.34	0.6939
0.10	0.2003	0.35	0.7152
0.11	0.2204	0.36	0.7366
0.12	0.2406	0.37	0.7581
0.13	0.2608	0.38	0.7796
0.14	0.2810	0.39	0.8012
0.15	0.3012	0.40	0.8230
0.16	0.3214	0.41	0.8449
0.17	0.3417	0.42	0.8669
0.18	0.3620	0.43	0.8890
0.19	0.3824	0.44	0.9112
0.20	0.4028	0.45	0.9336
0.21	0.4232	0.46	0.9561
0.22	0.4437	0.47	0.9787
0.23	0.4642	0.48	1.0014
0.24	0.4848	0.49	1.0242
0.25	0.5054	0.50	1.0472

[The above article may help to settle some of the points recently under discussion in these columns.—Editor.]

NEW PUBLICATIONS

HYDRAULIC TURBINES. By R. L. Daugherty. Published by McGraw-Hill Book Co., New York, 1913. Cloth, 6¼x9¼ in.; 156 pages, 96 illustrations, tables. Price, $2 net.

The purpose of the book is to give a general idea of water-power development and conditions affecting the turbine operation, a knowledge of the principal features of construction of modern turbines, an outline of the theory and the characteristics of the principal types, commercial constants, means of selection of type and size of turbine, and cost of turbines and water power.

In the limited space devoted to the subject the book covers the ground exceptionally well. For the most part it is simple and straightforward. The chapters on general theory and the theory of the various types of turbine naturally involve mathematics requiring a knowledge of trigonometry, and the same is true of the final chapter dealing with centrifugal pumps. The book may be recommended to students or to any one desiring a concise review of the entire subject of water power.

SHOP MATHEMATICS, Part II. Advanced Shop Mathematics prepared for the Extension Division of the University of Wisconsin. By Earl B. Norris and Ralph T. Craigo. Published by the McGraw-Hill Book Co., New York, 1913. Size, 6x9 in.; 214 pages, illustrated. Price, $1.50.

This book is an attempt to present the subject of applied mathematics, including elementary algebra, geometry and trigonometry, in a concrete rather than abstract form. For instance, algebra has been approached from the standpoint of engineering formulas, the authors pointing out that there is really nothing mysterious in such expressions, the symbols merely being more convenient to handle than the quantities they represent. Mensuration is handled in a very practical manner and free use is made of illustrations. The use of logarithms, trigonometric tables and curves is fully explained and, although in a few instances the authors have lapsed into the abstract the treatment of the subject in general and the selection of problems are thoroughly practical.

HEAT, A MANUAL FOR TECHNICAL AND INDUSTRIAL STUDENTS. By J. A. Randall. John Wiley & Sons, New York. Cloth, 5⅛x8 in., 331 pages; 77 illustrations; 15 tables. Price, $1.50.

Here is a book treating the subject of heat and thermodynamics that students and practical men alike have long felt the need of. The author has succeeded in his endeavor to furnish the general student or reader with such insight into the nature of heat and its effects as shall enable him to comprehend, reasonably, the operation of various power processes.

The author begins with an understandable treatment of the various forms of energy and leads into specific heat, calorimetry, expansion of gases and heat transmission by convection, conduction, radiation and treats on insulating materials.

The manner of treating the functions and heat exchanges and losses in steam, gas and refrigeration plants is, indeed, admirable. Simple shaded diagrams are used, and as the author does not resort to the usually inexcusable practice of using calculus and other higher mathematics in his treatment of the subjects, but instead requires only a knowledge of formulas from his readers, power-plant operating engineers will greatly appreciate the work, and find it of much value in giving them a good working knowledge of a branch of their work that they have left to the technical graduate for want of a proper book by which to acquire it themselves.

The technical man, too, will find it a valuable addition to his library.

HENDRICKS' COMMERCIAL REGISTER. Twenty-second annual edition. Published by Samuel E. Hendricks Co., New York City. Cloth; 1666 pages; 12x5½ in. Price, $10.

This well known register, established in 1891, has reached its 22d annual edition, which is forcible evidence of its wide use and usefulness. It furnishes complete classified lists of manufacturers for the benefit of those who want to buy as well as for those who have something to sell. It covers very completely the architectural, engineering, electrical, mechanical, railroad, mining, manufacturing and kindred trades and professions and establishes a direct link between the buyer and seller. The present is by far the most complete edition, requiring as it does 138 pages of index and representing the manufacturers of over 6000 articles, none of which has appeared in any previous edition. The total number of classifications is over 55,000, each representing the manufacturers or dealers of some machine, tool, specialty or material required in the architectural, engineering, mechanical, electrical, railroad, mine and kindred industries. There is a total of 437 pages of new matter, the whole representing upward of 390,000 names and addresses. An important feature is the simplicity of its classifications, which are so arranged that the book can be used for either purchasing or mailing purposes.

The value of the book for purchasing purposes is not confined to its complete classifications alone. It also gives much information following the names of thousands of firms that is of great assistance to the buyer and saves the expense of writing to a number of firms for the particular article required. There is also included the trade names of all articles classified as far as they can be secured. These trade names appear in parenthesis between the names and addresses under the classifications where they appear. The book is revised, improved and issued annually.

PRINCIPLES OF INDUSTRIAL ORGANIZATION—By Dexter S. Kimball. Two hundred and sixty-eight 6x9-in. pages; 19 illustrations; cloth bound; indexed. Price $2.50, McGraw-Hill Book Co., New York, N. Y.

This book is in a class by itself. No form or system of management is exploited in the book. No specific remedy for industrial evils is advocated. But the best of the modern systems and methods are presented through their principles with a careful weighing of advantages and disadvantages. Details, cards and forms are omitted. Thus this book stands head and shoulders above the ordinary run of management writings.

The book is the outgrowth of a series of lectures given by the author for the past few years to senior students at Sibley College, Cornell University. It is intended primarily for the needs of the young engineer, but its field of usefulness is much wider. Every practicing engineer or shop manager should have a definite knowledge of the principles of the various systems of management offered to him today.

Of the 14 chapters, the first four deal with the great inventions, their effects and corrective influences in industry. The first outlines the fundamental principles of the factory system, and the system that immediately preceded the present methods. Chapter 4 is concerned with corrective influences which are active at the present day.

Chapter 5 is devoted to "Modern Industrial Tendencies," taking up such matter as specialization, standardization, interchangeability, and the division of mental and manual labor. This is followed by a chapter on the forms of industrial ownership, and these six pave the way for the treatment of the principles of organization, in Chapter 7.

Chapters 8 to 12, inclusive, deal with specific features of factory organization. These are: Planning Departments; Principles of Cost Keeping; The Depreciation of Wasting Assets; The Compensation of Labor; Purchasing, Storing and Inspection of Materials.

Chapter 13 is devoted to the location, arrangement and construction of industrial plants, and the final chapter treats of theories of management. This is really a resumé and statement of the principles underlying industrial management, with a brief discussion of each. The discussion of these is most illuminating, and clears many points around which there has been controversy. It is gratifying to note that only seven principles are recognized, for previous writers have attempted to give anywhere from a dozen to seventeen or more.

An important feature of the work is frequent references to transactions of the American Society of Mechanical Engineers, other books and current technical literature. These recognize and point out the importance of the work of such men as Halsey, Taylor, Gantt, Church and Emerson. Thus the book has been written from a most careful study of the best of industrial management and practice of today, and with a full appreciation of its possibilities and importance.

New Government Publications—The Bureau of Mines of the Department of the Interior has the following new publications. Bulletin 50, a laboratory study of the inflammability of coal dust, by J. C. W. Frazer, E. J. Hoffman and L. A. Scholl, Jr., 60 pages, 95 illustrations. Bulletin 22, Analyses of coals in the United States, with descriptions of samples collected between July 1, 1904, and June 30, 1910, by N. W. Lord, with chapters by J. A. Holmes, T. M. Stanton, A. C. Fieldner and Samuel Sanford. Part I, Analyses, pages 1-321, 1 illustration; Part II, Descriptions of Samples, pages 322-1200. This bulletin gives information of value to fuel-purchasing agents, mechanical engineers and other persons who wish to know the composition and heating value of different coals. It is not published for general distribution. Not more than one copy of either bulletin will be given to the same person. Requests for the publications should be made by number and title and addressed to the Director of the Bureau of Mines, Washington, D. C.

BOOKS RECEIVED

POWER-PLANT TESTING. By James A. Moyer. McGraw-Hill Book Co., New York. Second edition; cloth; 486 pages, 6x9 in.; 393 illustrations; tables. Price, $4.

ADVANCED SHOP MATHEMATICS. Part II. By Earle B. Norris and Ralph T. Craigo. McGraw-Hill Book Co., New York. Cloth; 214 pages, 6x9 in.; 218 illustrations; tables. Price, $1.50.

TECHNICAL GAS AND FUEL ANALYSIS. By Alfred H. White. McGraw-Hill Book Co., New York. Cloth; 276 pages, 5½x8¼ in.; 47 illustrations; tables. Price, $2.

PROCEEDINGS OF THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION. Published by the Society at Ithaca, N. Y. Cloth; 508 pages, 5¾x8¾ in.; illustrated. Price, $1.25.

THE POLYTECHNIC ENGINEER. Published annually by the Polytechnic Institute, Brooklyn, N. Y. Cloth; 138 pages, 6x9 in.; illustrated.

STEAM, ITS GENERATION AND USE. The Babcock & Wilcox Co., New York. Cloth; 335 pages, 7¼x10¼ in.; tables; illustrated.

TABLE OF ESTIMATED RADIATION. By Harry B. Perrigo, New Haven, Conn. Celluloid folder, 4½x7¼ in. Price, $1.

Greater Winnipeg Water Project

The engineering organization for the $13,000,000 Canadian water project of the Greater Winnipeg water district is being rapidly assembled, states "Engineering Record." On Oct. 4 members of the administration board chose S. H. Reynolds, of Victoria, as the first of three commissioners to handle the construction and J. H. Fuertes, consulting engineer, of New York, as consulting engineer to the commission. W. G. Chace, of Toronto, was appointed chief engineer.

Surveying for the project has started, and as soon as the rights-of-way have been secured a telephone line will be installed between Winnipeg and Shoal Lake, the source of the proposed supply.

The officials expect that actual construction will be begun next spring, and recommend, in view of the fact that the region is difficult of observation in the winter and spring, that prospective bidders visit the district at an early date.

Campello (Mass.) Boiler Explosion

At 6:40 o'clock on the morning of Thursday, Oct. 9, while opening the throttle valve on a 20x42-in. Brown engine, at the factory of George E. Keith Co., shoe manufacturers, Campello, Mass., a cast-iron elbow under the valve ruptured. The flying fragments and escaping steam so severely injured and scalded the engineer, Alonzo E. Nelson, as to necessitate his removal to the Brockton Hospital.

Nelson was alone in the engine room when the accident occurred and was presumably warming up the engine for the day's run. As his condition is such as to preclude the securing of his statement, the cause can only be conjectured.

It is thought that the failure was induced by a slug of water carried along with the flow of steam and the consequent impact at the elbow being sufficient to cause the rupture. Steam and water continued to issue through the break until the arrival of the fire department, which was summoned by the operating of the automatic fire alarm, when the fires were drawn and the stop valve closed.

Nelson has been employed by the concern for 32 years and this is his second serious accident. About four years ago there was an explosion of gases in the boiler room that nearly cost him his life and he was confined in the hospital for several weeks.

Problems of Technical and Industrial Education

In Philadelphia last spring, representatives of the Central Educational Institute of the Y. M. C. A., Drexel Institute, the Franklin Institute, School of Industrial Arts, Spring Garden Institute, Temple University, and the Wagner Free Institute of Science joined with representatives of the Philadelphia Trades Schools and the Philadelphia and Camden Public Schools in arranging meetings for the purpose of becoming acquainted with one another's work and the educational problems employers have to face. Wishing to avail themselves of the wide resources of the Public Education Association of Philadelphia, members of the faculties of the participating institutions are now organizing a section of that association to be known as the Industrial and Technical Education Conference of the Public Education Association. The membership is to consist of educators and employers, and the purpose is to seek the solution of the problems arising from the needs of the vast numbers of young people who have never had proper opportunities for securing that knowledge which will pave the way to better service and higher responsibilities.

Arthur J. Rowland is chairman and Henry V. Gummere, secretary of the conference. It is hoped that the movement thus started will spread to include not only local representatives, but all those employers whose employees find in the large city opportunities which cannot be offered nearer. This means extending the work to a great many miles from Philadelphia, for classes could easily be arranged outside the city managed by experienced teachers who are specialists in any given line of instruction.

SOCIETY NOTES

The Ohio Society of Mechanical, Electrical and Steam Engineers will hold its eleventh annual meeting at Columbus, Ohio, on Nov. 20 to 22. The election of officers will take place and some interesting papers will be read and discussed.

The Chicago Section of the American Society of Mechanical Engineers proposes holding four meetings this season. It is planned to have a dinner at each meeting and maintain an informal discussion. The subjects for the meetings will be "The Iron and Steel Industry of the Chicago District," "Steam Power Plants," "Internal-Combustion Engines," and "Refrigeration." The first meeting will be held at the Sherman House on the evening of Nov. 19, at which the principal speaker will be William A. Field, general superintendent of the Illinois Steel Co.'s plant at South Chicago.

"A New Centrifugal Pump with Helical Impeller" is the title of a paper to be presented at the regular monthly meeting of the American Society of Mechanical Engineers on Tuesday evening, Nov. 11, by C. V. Kerr, of the A. S. Cameron Steam Pump Works, New York. The reason for seeking a new type of pump is based on the characteristic behavior of the small steam turbine which is commonly used in power plants as the driving power for circulating pumps for condensers. The mathematical theory of the new type of impeller will be presented, also an illustrated description of the 8-in. experimental pump used, with methods and results of tests. Discussion will follow in which all are invited to take part. An informal dinner will be served at 6:30 p.m.

PERSONALS

H. W. Thompson is the new superintendent of the Azusa (Calif.) municipal light and power plant.

Fred L. Hunt was recently appointed chief engineer of the Greenfield (Mass.) Electric Light & Power Co.

A. H. Maynard is the new chief engineer of the Merchants Lighting Co. power plant at Little Rock, Ark.

E. A. Geoghegan, for the past two years with the Union Iron Works, Erie, Penn., has accepted a position as superheating specialist, with the Erie City Iron Works, Erie, Penn.

Etienne de Fodor, general director of the General Electric Co. of Budapest, tendered a banquet to 150 distinguished Hungarians on Oct. 9, to mark the twentieth anniversary of the company.

L. G. Denis, hydro-electric engineer for the Canadian Conservation Commission, recently completed a 1000-mile canoe trip in the investigation of water-power possibilities in northern Manitoba.

Dan Cubberly, for many years with George B. Carpenter & Co., Chicago, has been made vice-president of the Julius Pearse Fire Department Supply Co., Denver, Colo., and will henceforth devote his entire time to the interests of that company.

J. B. Shatzer, representing the Schutte & Koerting Co., of Pittsburgh, Penn., will give a "Safety First" lecture, covering automatic engine stops and triple service valves at the National Association of Stationary Engineers' regular meeting to be held in Pittsburgh, on Nov. 17.

POWER

Vol. 38 NEW YORK, NOVEMBER 18, 1913 No. 21

Self Interviews

THE *place is the private office of J. Jeffrey Willock, manufacturer and chief owner of the biggest group of mills in B———, Penn. Time, the present. J. Jeffrey is pacing the floor in rage over the report his new chief engineer, when J. Jeffrey Willock enters.*

□ □ □

"Willock," says the newcomer, "why this burst of anger?"

"Why? Why?" roars J. Jeffrey, "why that infernal idiot of an engineer reports that the plant's a veritable nk heap! That it wastes money like a drunken sailor! And he calls for an expenditure of $20,000 for new uipment."

"Think of it! Paying him $5000 a year to tell me how to waste $20,000. An idiot, I say, an idiot!"

"Calm yourself, Willock, analyze the case; you'll see things differently," went on his more placid self.

"Calm nothing! You're worse than he is. Get out!"

"Willock," protested the other, "your last two engineers—good men—made similar recommendations. They arned you of the weakness of the present equipment, and told you of inevitable delays and losses due to accidents id repairs."

"You ignored them both. You knew better. In your mad eagerness for big dividends you avoided needed penditures. Now comes the reaction. Better take his tip, Willock."

Ting a ling a ling, ling. The phone rang violently.

"Engineer? Yes. What! Great God!" exclaimed Willock as he faced himself. "It's here. The main engine's racked her frame and the flywheel's fractured. Sudden heavy overload."

"The engineer's right; I'm the idiot. But I've discovered it too late."

Flatbush Gas-Electric Station

By Charles H. Bromley

SYNOPSIS—Initially a gas plant erected in 1864 to supply the town of Flatbush, now the 29th Ward of the Borough of Brooklyn, City of New York. In 1893 an electric plant was installed. At present the electric station is evoluting from a reciprocating to an uptodate turbine installation. The water in the tank of a 5,000,000-cu.ft. gas holder furnishes water for the turbo-jet condensers. The plant buildings are heated by boiler-feed water taken from an open heater. Large tandem gas engines driving exhausters handle the gas-distribution system.

Often there is little variety in the general layout of power plants, but the plant of the Flatbush Gas Co. has some unusual features of operation and these will here be described.

Boiler and Engine Rooms

The plant initially was a small gas property erected to supply the then thinly scattered community of the town of Flatbush. A desire to have electric-arc street lighting then sprang up and horizontal tandem steam engines belted to Excelsior arc-light machines were installed; then came a desire to have incandescent electric lighting and belted two-phase, 60-cycle, 2200-volt generators driven by high-speed horizontal cross-compound steam engines were installed, this system enabling both arc and incandescent lighting to be done from the same type of machine. The belt-driven units were followed by cross-compound vertical engines direct connected to 60-cycle,

Two 520-hp., two 250-hp., one 440-hp. and one 383-hp. hand-fired water-tube boilers with a total capacity of 2363 hp., normal rating, furnish steam for the electric plant. All boilers carry 160 lb. steam pressure and operate on a balanced-draft system. The four larger boilers are equipped with 150-deg. F. superheaters, the superheat being 80 deg. F. at the turbines. The boilers are equipped

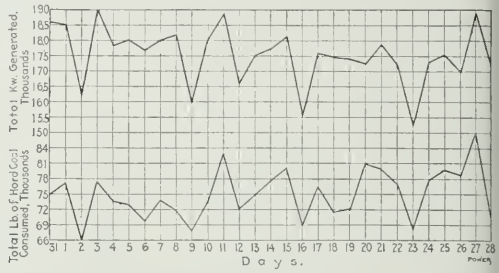


Fig. 3. Coal Consumption and Kilowatt Curves for February, 1913

with recording gages for the balanced draft, steam temperature and steam pressure. No. 3 buckwheat coal with a mixture of 3 per cent. soft coal is burned under all boilers. The weight of coal delivered to the yard and to each boiler is recorded daily. Average CO_2 samples are collected on all runs and analyzed twice daily. Each shipment of coal is analyzed by the company's chemist.

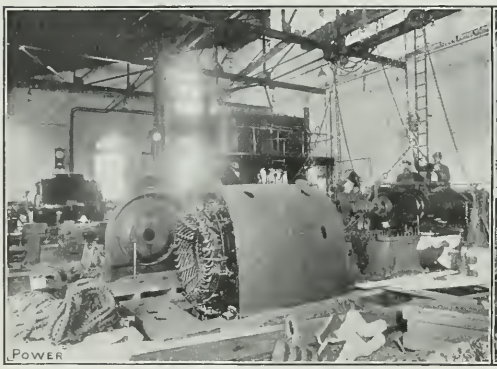


Fig. 1.

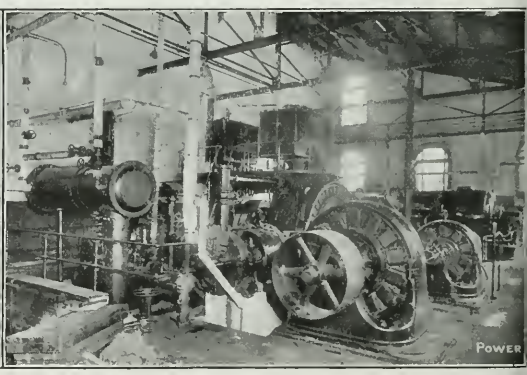


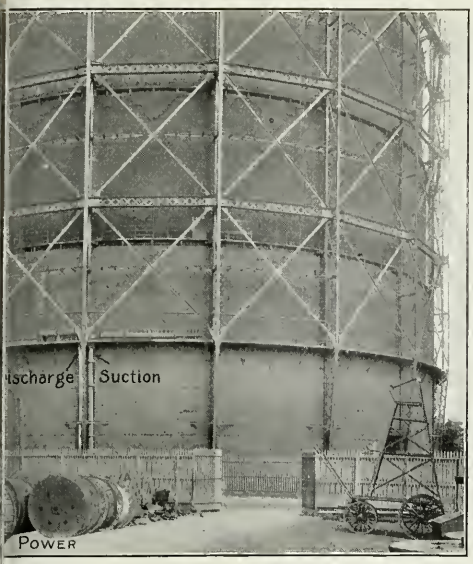
Fig. 2.

Evoluting from a Reciprocating Engine to a Modern Turbine Installation

2200-volt, two-phase alternators, these vertical units being installed about 1900. All the Excelsior and Brush machines, together with the horizontal engines, have disappeared, and of the old equipment, there remain but the two vertical direct-connected units shown in Figs. 1 and 2. These two photographs show the turbines installed and the evolution which has taken place in the last 13 years from engine to turbine practice. With the completion of the turbo-unit now being installed the plant will have a capacity of 5375 kw. The switchboard is of the direct-control type.

The boiler-feed water is taken from the hot wells into which the condenser water discharges. The makeup water for the loss from the cooling towers and water used around the plant is obtained from the company's well. Curves showing daily coal consumption and kilowatt output, as well as tables showing how excess air and various percentages of CO_2 affect the boiler economy are hung in the boiler room for the guidance of the men. The interest which these tables and curves stimulate in the men is well worth the trouble in posting.

Fig. 3 shows the coal-consumption kilowatt-output



IG. 4. CONDENSER-CIRCULATING-WATER HEADERS ON 5,000,000-CU.FT. GAS HOLDER

rves which are plotted and hung in the boiler room. ote how closely the coal curve follows the kilowatt-out- t curve, no doubt reflecting the interest shown by the gineers and firemen, resulting in the elimination of ky boiler settings, improved firing methods, and a gen- l pride in the results.

CONDENSING SYSTEM

The condensing system is indeed interesting insofar as utilization of the circulating water is concerned. As is generally known, gas holders are provided with water seals on the different sections to prevent escape of gas. Naturally these seals must be prevented from freezing in the winter. The holder in Flatbush, a part of which is shown in Fig. 4, is of 5,000,000 cu.ft. capacity, the tank of which contains approximately 8,250,000 gal. of water. To keep this great amount of water from freezing in winter requires about 100 boiler horsepower per hour

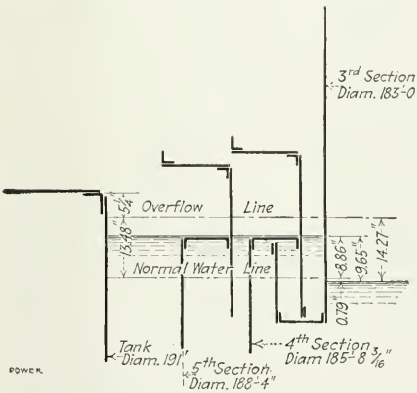


FIG. 5. PARTIAL SECTION OF GAS HOLDER, SHOWING WATER SEALS WHEN THREE SECTIONS ARE INFLATED

with the atmospheric temperature near the freezing point. Fig. 5 is a sectional elevation showing two of the seals in the gas holder. As the plant is at a considerable distance from a cheap and plentiful cold-water supply for circulating purposes, the water in this holder tank is being made use of. The turbo-jet condensers are connected to the huge tank of the gas holder which serves both as a reservoir and cooling pond for the circulating water from the turbo-condensers. Owing to the load on the turbines the circulating water of the condensers contains suffi-

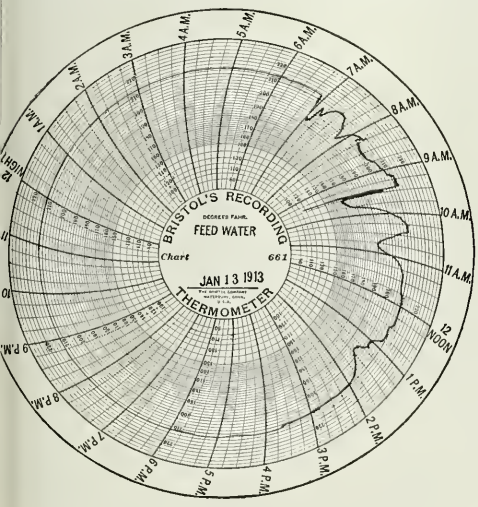


FIG. 6.

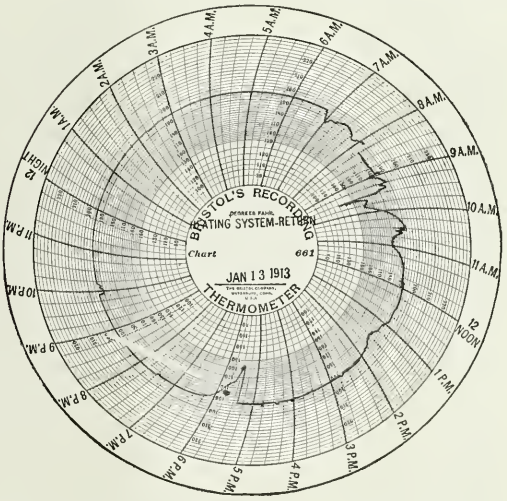


FIG. 7.

HEATING SYSTEM CIRCULATING (BOILER FEED) WATER TEMPERATURE CHARTS, SUPPLY AND RETURN

cient heat, even in exceedingly cold weather, to keep the tank at a temperature of about 90 deg. F. Due to the heavy supply of gas to the distribution system at peak hours, nearly all the cups are submerged for a short time each day, giving a new supply of warm water to the seals, which keeps them from freezing when they again emerge from the tank. This process makes it possible to dispense with the boiler used for heating the gas holder and it enables the engineers to get about 2 in. of vacuum more than they could obtain by cooling the water in their regular standard cooling towers. The whole effect is a saving of approximately $5000 a year on the coal bill.

Originally the water was conducted direct from the holder to the condensers. Later it was found that much better results were obtained by passing the water over the cooling tower, which gave it an additional cooling effect, and also discharged the vapor which may have dissolved in the water. Curves of the temperature of the water and atmosphere have shown that it is only in the most unusually severe winter weather that the seals are likely to freeze with this system of heating. Water from the condensers is discharged into the hotwells and then pumped into the tank of the gas holder. From all that the writer can learn this is the first time that such a condensing system was ever conceived of or put in successful operation. The scheme in its entirety was worked out by the engineering force at the plant.

Feed Water for Heating

The boiler-feed water is used to heat the comparatively small, though numerous, buildings about the works. Examination of the charts, Figs. 6 and 7, shows a small temperature difference between the supply and return water. This is due to the high velocity at which the water is forced throughout the system and not because there is inadequate radiation. One 2-in., two-stage a one 2-in., single-stage centrifugal pump direct connec to 5-hp. induction motors are used for this purpose. T

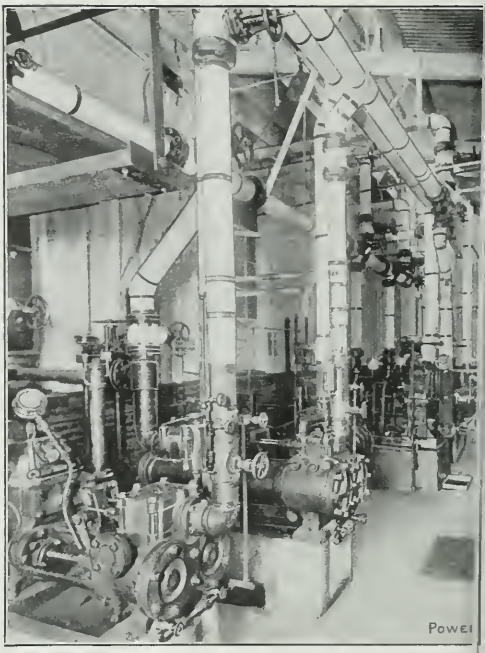


Fig. 8. Note the Well Laid Out Piping in This Pump Room

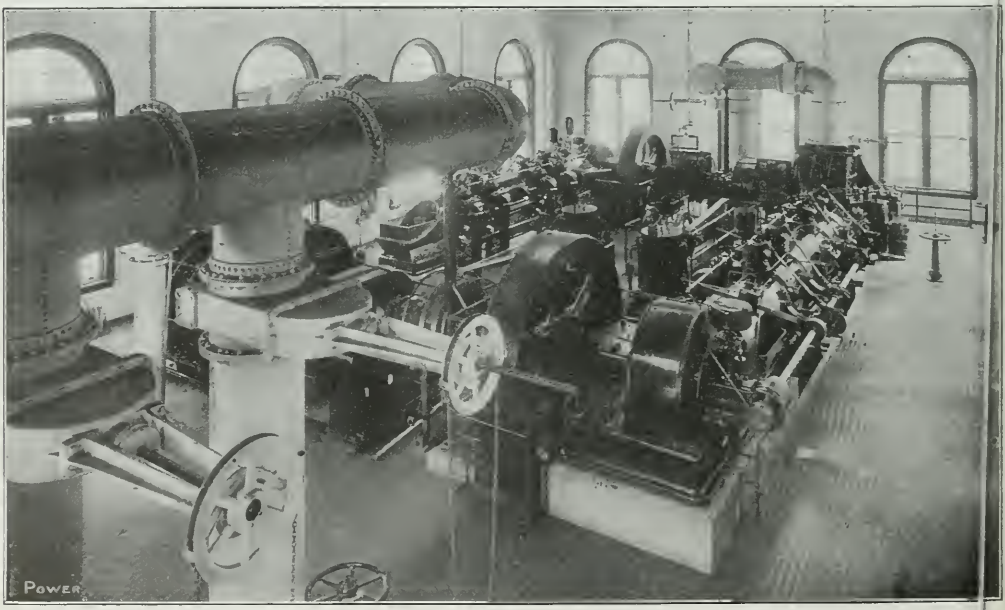


Fig. 9. The Double-Acting Tandem Gas Engines Driving Blowers for Gas-Distribution Syste

second pump is operated only in extremely cold weather. The water used for heating is metered on entering the system, and as the temperature of both the supply and return is recorded and the average heat value of the fuel is known, it is easy to determine how much coal should be charged to the heating system.

The equipment of feed pumps, Fig. 8, is quite complete to insure noninterrupted service. There are two duplex reciprocating pumps, two 3-in., three-stage, steam-driven turbine pumps, and a 3-in., four-stage motor-driven pump which can be used in case of emergency. Dresser fittings are used in the feed-pump suction lines to allow for quickly disconnecting the line for cleaning.

Gas Engines for Holder Service

The two tandem double-acting gas engines shown in Fig. 9 are of 400 hp. each, using illuminating gas of 660 B.t.u. per cu.ft. The engines are direct connected to exhausters, running at 155 r.p.m. and capable of delivering 750,000 cu.ft. of gas per hour against 5 lb. pressure. During the day the holder is filled with gas from a pressure main and when there is a large demand the engines pump the gas from the holder back into the pressure main whence it is delivered through governors into the distribution system at a constant pressure.

English Boiler Explosions

The annual report for the year ended June 30, 1912, on the working of the Boiler Explosion Acts, 1882 and 1890, has just been issued by the Board of Trade. During the period named 100 preliminary inquiries and six formal investigations were held under the provisions of the acts. The 106 explosions thus dealt with caused the death of 30 persons and injury to 75 others.

It is interesting to note that in 20 out of the 27 explosions which occurred on ships no person was injured and that in the remaining seven explosions 13 persons were killed and four injured.

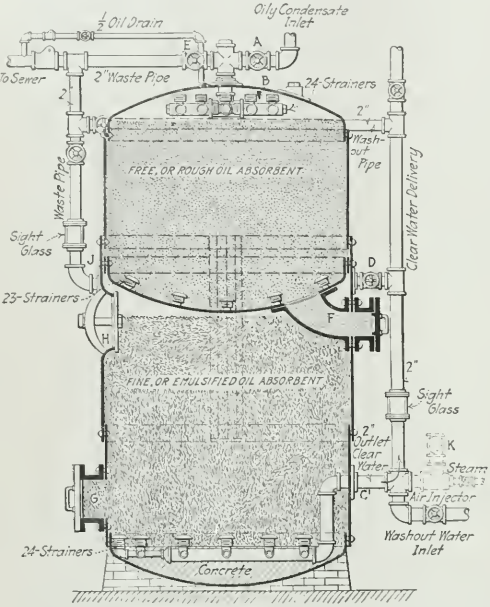
The number of persons killed during the year from the explosion, etc., of boilers on land and sea is above the average (26.3) for the 30 years since the acts came into force, and compares unfavorably with the comparatively low death rate during the preceding three years, in which the average was only 13. This is very largely due, the report states, to two explosions, in each of which six persons were killed. There were 10 explosions from heating apparatus during the year; nine of these occurred during the cold weather at the beginning of February, 1912, and were all due to the pipes being obstructed by ice.—*The Power User.*

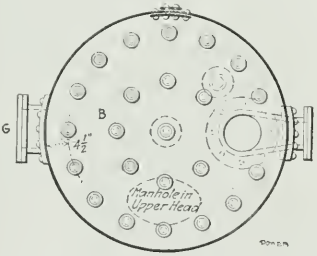
PRINCIPAL EQUIPMENT OF THE FLATBUSH GAS COMPANY'S PLANT

No.	Equipment	Kind	Capacity	Dimensions	Operating Conditions	Manufacturer
2	Boilers	Water tube	520 hp. each		160-lb. pres. main units supply	Babcock & Wilcox Co.
1	Boiler	Water tube	440 hp.		160 lb. pres. main units supply	Babcock & Wilcox Co.
1	Boiler	Water tube	393 hp.		160 lb. pres. main units supply	Babcock & Wilcox Co.
2	Boilers	Water tube	250 hp. each		160 lb. pres. main units suppl.	Babcock & Wilcox Co.
4	Superheaters				St. 150 deg. F., superheat	Babcock & Wilcox Co.
2	Main engines	Vertical cross comp.	450 hp. each	19x38x18	190 r.p.m., 25-in. vac.	Ball & Wood Co.
1	Main turbine	Horizontal reaction	750 kw.		1800 r.p.m., 27-in. vac.	Allis Chalmers Co.
1	Main turbine	Horizontal reaction	2500 kv.a.		1800 r.p.m., 27-in. vac.	Allis Chalmers Co.
1	Main turbine	Double flow (reaction and impulse)	3125 kv.a.		3600 r.p.m., 29-in. vac.	Westinghouse Elec. & Mfg. Co.
2	Main generators	A. C.	300 kw. each		2 phase 60 cycle 2260 volts	Westinghouse Elec. & Mfg. Co.
1	Main generators	A. C.	750 kw.		2 phase 60 cycle 2400 volts	Allis Chalmers Co.
1	Main generators	A. C.	2500 kv.a.		2 phase 60 cycle 2400 volts	Allis Chalmers Co.
1	Main generators	A. C.	3125 kv.a.		2 phase 60 cycle 2400 volts	Westinghouse Elec. & Mfg. Co.
1	Switchboard	Gray marble			Direct control	General Electric Co.
1	Condenser	Le Blanc Jet		3125 kv.a.	Turbine service	Westinghouse Machine Co.
1	Condenser	Tomlinson jet		2500 kv.a.	Turbine service	Allis Chalmers Co.
1	Condenser	Connersville jet		750 kw.	Turbine service	Connersville Blower Co.
1	Condenser	Worthington jet		9x14x15	Reciprocating eng. service	Worthington Steam Pump Co.
2	Feed pumps	Reciprocating		10x6x10—7½x14x10	Boiler feed	Worthington Steam Pump Co.
2	Feed pumps	Centrifugal	200 g.p.m. against 200 lb. pressure	3″.	4 stage 2400 r.p.m. turb. driven	Alberger Pump & Cond. Co.
1	Hydraulic pumps	Centrifugal	300 g.p.m. against 175 lb. pressure	5″.	3 stage 1800 r.p.m. motor driven	Alberger Pump & Cond. Co.
2	Hot water cir. pumps	Centrifugal	100 g.p.m. against 195′ head	2″.	2 stage 1800 r.p.m. motor driven	Alberger Pump & Cond. Co.
1	Cir. pump	Volute	2500 g.p.m. against 50′ head	10″.	1 stage 900 r.p.m. motor driven	Buffalo Pump Co.
1	Cir. pump	Volute	3000 g.p.m. against 50′ head	10″.	1 stage 900 r.p.m. motor driven	Buffalo Pump Co.
1	Cir. pump	Volute	3000 g.p.m. against 50′ head	10″	1 stage 900 r.p.m. motor driven	Alberger Pump & Cond. Co.
1	Well pump	Centrifugal	250 g.p.m. against 195′ head	3″	3 stage 1800 r.p.m. motor driven	Alberger Pump & Cond. Co.
4	Motors	Induction	50 hp. each		2 phase 60 cycle 2200 volts 900 r.p.m.	General Electric Co.
1	Motor	Induction	50 hp.		2 phase 60 cycle 220 volts, 514 r.p.m.	General Electric Co.
1	Motor	Induction	50 hp.		2 phase 60 cycle 2200 volts 1800 r.p.m.	General Electric Co.
1	Motor generator	Synchronous	75 kw.		2 phase 60 cycle 2200 volts 720 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Motor generator	Synchronous	180 kw.		2 phase 60 cycle 220 volts 514 r.p.m.	Westinghouse Elec. & Mfg. Co.
1	Motor	Induction	5 hp.		2 phase 60 cycle 220 volts 1800 r.p.m.	General Electric Co.
1	Motor	Induction	75 hp.		2 phase 60 cycle 220 volts 3600 r.p.m.	General Electric Co.
2	Turbines	Steam	45 hp.		150 lb. press., 2400 r.p.m., pump driven	Terry Steam Turb. Co.
1	Turbines	Steam	125 hp.		150 lb. press., 1350 r.p.m., pump driven	Terry Steam Turb. Co.
1	Cooling tower	Forced draft	40,875 sq.ft. cooling surface.		2 7-ft. fans, 150 r.p.m.	The Flatbush Gas Co.
1	Cooling tower	Natural and induced draft	63,000 sq.ft. c.s.		1 10-ft. fan, 180 r.p.m.	Alberger Pump & Cond. Co.
1	Cooling tower	Worthington			1 7-ft. fan, 150 r.p.m.	Worthington Pump & Cond. Co.
2	Feeder regulators		200 amp.		2300 volts	General Electric Co.
4	Feeder regulators		150 amp		2300 volts	General Electric Co.
1	Motor generator set		25 kw.		125 volts	Westinghouse Elec. & Mfg. Co.
2	Exciter	D. C.	11 kw.			Westinghouse Elec. & Mfg. Co.
1	Exciter generator	D. C.	35 kw.		115 volts 318 amp., 3600 r.p.m.	General Electric Co.
1	Exciter turbine	Impulse	35 kw.		150 lb. pressure 3600 r.p.m.	General Electric Co.
2	Gas engines	Tandem	400 hp.		Illuminating gas 660 B.t.u., 175 r.p.m.	Buckeye Engine Co.
1	Constant current transformers	Oil cooled	68 kw.		100 light type r.o., 2200 volts	General Electric Co.
1	Constant current transformers	Oil cooled	34 kw.		50 light type r.o., 2200 volts	General Electric Co.
1	Constant current transformers	Air cooled	71 kw.		100 light type r.n., 2200 volts	General Electric Co.
1	Constant current transformers	Oil cooled	68 kw.		100 light type r.o., 2200 volts	General Electric Co.
1	Constant current transformers	Oil cooled	34 kw.		50 light type r.o., 2200 volts	General Electric Co.
1	Constant current transformers	Oil cooled	34 kw.		50 light type r.o., 2200 volts	General Electric Co.
1	Constant current transformers	Air cooled	71 kw.		100 light type r.o., 2200 volts	General Electric Co.
1	Constant current transformers	Oil cooled	34 kw.		50 light type r.o., 2200 volts	General Electric Co.
1	Constant current transformers	Air cooled	30 kw.		50 light type r.o., 2200 volts	General Electric Co.
1	Constant current transformers	Air cooled	35 kw.		50 light type r.n., 2200 volts	General Electric Co.
1	Constant current transformers	Air cooled	30 kw.		50 light type r.n., 2200 volts	General Electric Co.
1	Constant current transformers	Oil cooled	34 kw.		50 light type r.o., 2200 volts	General Electric Co.

Krause Absorbent Oily Condensate Filter

The illustration herewith shows a filtering apparatus designed to completely remove the emulsified oil or grease from oily- and cloudy-looking condensate coming from steam separators, feed-water heaters, traps, surface condensers and pipe drips of all kinds, so that the purified water, instead of being run to waste, may be reused as a boiler-feed water and for other purposes where clear and clean water is required.





Details of Filter Construction

The filter is divided into an upper and a lower compartment, the upper compartment removing the rough or floating oil by means of finely divided granular coke, flue dust or other suitable straining material. The lower compartment contains a patented combination of a fibrous absorbent silicate mixed with a granular mineral, also having strongly absorbent properties.

The condensate to be purified enters at *A*, through the strainers or sand valves *B* and passes downwardly through the upper layer of fine coke or other straining bed, leaving therein all of the rough oil from the condensate or drips from steam lines and heating system returns.

After passing through the upper bed, the condensate, which then contains only the emulsified oil, heretofore found impossible to filter, passes into the lower strainers and thence onto and through the lower bed or layer of absorbent material, wherein the last traces of oil are absorbed or removed from the water, so that after the water emerges it leaves the outlet pipe *C* perfectly clear and may then be pumped directly into the boiler or to a feed-water heater.

This filter may be worked either by gravity where the head is sufficient, or a pressure pump may be used.

After the upper layer has strained out the rough oil from the water a reverse current of hot water is admitted from time to time through the pipe *D*; the inlet valve *A* is closed and the outlet valve *E*, controlling the waste pipe, is open. As the granular material in the said upper compartment only acts as a strainer, it is retained within the filter by means of the sand valves which permit the oil and oily water only to pass through. When this granular material is, from time to time, worn down and becomes too fine it may be removed through the nozzle *F*. New straining material is then introduced through a manhole in the upper dished head.

When the fine or emulsified oil absorbent in the lower compartment is saturated or exhausted, which may take several months, it is removed through the lower nozzle *G*. A new charge of absorbent is then introduced through the manhole *H*.

Instead of wasting the rough oil from the upper compartment by emptying it into the sewer, it may be collected in a special tank from which it may be floated off and again purified by any of the well known methods. As no chemicals or solvents are used in the filtering process, and as the absorbent used is entirely neutral this tends to render the subsequent purification of such oil very simple.

Provision is made to agitate and break up, by means of a reverse current through the lower strainers, the layer of oily matter which gathers from time to time upon the upper surface of the absorbent in the lower compartment.

This oily scum and saturated absorbent may then be discharged into the sewer or other receptacle through the vertical waste pipe connected at *J* to the upper end of the lower compartment.

Steam and air to agitate the absorbent are introduced by means of an air injector and steam connection, as shown at *K*.

This process, which is patented in this and other countries, works with either hot or cold water, requires no chemicals, alum, or other solvents and is a direct process of filtration capable of rendering the condensate perfectly clear and free from oil, and is now giving entire satisfaction in numerous installations.

When arranged horizontally, so as to require less height, this filter is readily adapted for marine use, where a clean feed water is even more in demand than it is on land, and where the dangers of using oily feed water are much more serious.

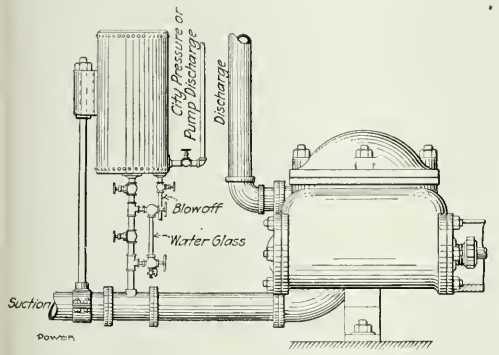
Where efficient oil separators in the steam line are used or an effective separation of the coarser oil is carried out by means of turkish towelling or multi-screen filters, the upper chamber of this absorbent filter is arranged to give double the filtering capacity by omitting the coarse granular bed and substituting the fibrous absorbent instead.

This filter is built in any size up to 12 ft. in diameter, depending upon conditions, by A. E. Krause, 345 Fairmount Ave., Jersey City, N. J.

Boiler Graphite Feeder

A satisfactory feeder for boiler graphite is illustrated herewith. It consists of a reservoir and piping equipped with valves by which the reservoir may be cut out from all water pressure. When the water-inlet valve is opened and the city water pressure is applied to the reservoir, a combination of water and graphite is fed through an outlet valve at the bottom of the reservoir into the feed water on the suction side of the pump. The amount of water saturated with graphite passing to the pump can be adjusted by noting how fast it is traveling through the water glass.

When the contents of the reservoir become exhausted the valves are closed and the reservoir is emptied through



Piping of the Graphite Feeder

a drain valve. After draining off the clear water the reservoir is again filled with graphite and the feed regulated as before.

The illustration shows the manner in which the feeder, which is made by the United States Graphite Co., Saginaw, Mich., is connected with the pipe line at the suction side of the pump.

Combo Combination Water Column

The combination water column, described herewith, is simple in design, compact and is a combination of water column, whistle alarm, electric water gage, recording panel and graduated feed-water regulator attachments, which are operated by a compound lever system of hinged-pin construction contained within the main body. It is manufactured by the Combo Engineering Co., Inc., Union Springs, N. Y. This lever system is brought outside on small hinged shafts upon which are mounted levers to operate all attachments.

Inside of the main body, Fig. 1, a large float valve is connected to the main lever which is hinged on a shaft and operates the individual levers. The whistle, Fig. 2, is mounted upon the upper head; the operating lever is connected by two rods to a rocker-arm fitted upon the shaft mentioned. As the water level changes the rocker-arm rotates, and as the rods are provided with adjusting locknuts, the whistle levers can be regulated to blow the whistle at any high- or low-water level desired.

On the upper side of the upper head, opposite the whistle lever is a lever connecting the main shaft with

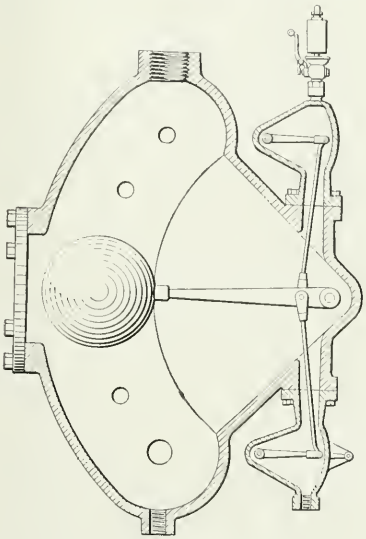


Fig. 1. Section through Main Body of Column

terminals which are connected by wires to the signal gage, which consists of five lamps connected to as many contacts on the alarm head. The contacts are in definite relation to the water level so that the lamp corresponding to the exact water level is always lighted. Several

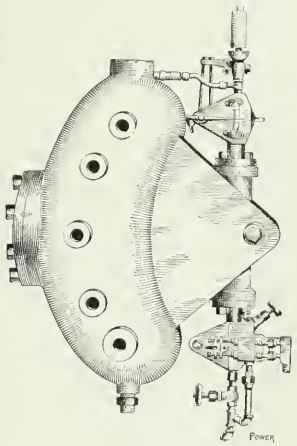


Fig. 2. Exterior View of Water Column

gages can be connected to a unit. The lamps at the top and bottom have red bulbs. A buzzer can be connected with the lamps for high and low water.

A special valve regulates the flow of feed water. It is connected to the lower head and is operated by the lever system inside the column. When the boiler is steaming

the water level is maintained at any point above or below the middle gage by regulating an adjusting screw which changes the time when the four contacts unseat the disk valves in the special valve with relation to the position of the float, which is at the actual water level in the boiler.

Ideal Indicator Hook

This little device has been designed to connect the indicator cord with the pin on the engine crosshead with ease and certainty, under any conditions and at any speed. In Fig. 1 is shown the hook in position to connect to the crosshead arm or any other device moved by the crosshead.

By holding the shank of the hook lightly between the fore and middle finger, as shown, and advancing the hand until the moving arm strikes the trigger of the hook, the spring and hook incloses the arm. As the arm moves in the opposite direction the hook is carried away from the fingers. This enables the operator to make connection without injury to himself, or trouble in performing the operation.

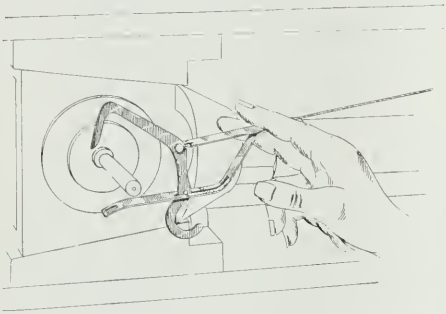
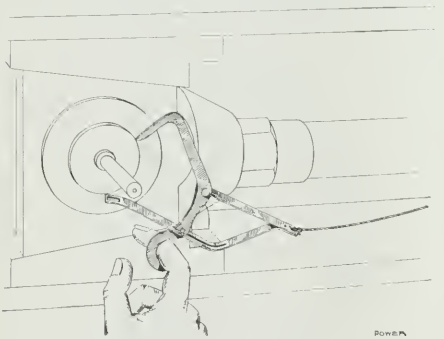


FIG. 1



Hooking On and Off Ideal Indicator Hook

In Fig. 2 is shown the releasing position. By placing one finger beneath the cord and then advancing it far enough to engage the curved end of the trigger, the hook will be disengaged from the arm and the device will be left suspended on the operator's finger. The hook will work in any position, and with either a round or flat arm. It is made of steel, nickel-plated, and weighs less than one ounce. It is manufactured by Joseph Stewart, 406 East Millville Ave., Hamilton, Ohio.

Loosened Idler Pulley Wrecks Flywheel

By Lloyd V. Beets

The accompanying illustration gives an idea of the havoc wrought by the recent bursting of a 40-ton flywheel in the engine room of the Liberty Flouring Mills, South Nashville, Tenn.

The 32x60-in. Corliss engine was developing about 1800 hp. The 22-ft. flywheel was double, as shown, each

Peculiar Freak of Flywheel Explosion

wheel having a 36-in. face or a combined face of 6 ft. The spokes broke off short at one hub, but the spokes on the other were left intact with a little of the rim adhering to them. Portions of the wheel went through a thick brick wall, making an opening 11x30 ft. in size, wrecking a box car on a siding outside of the building, in which a negro laborer was killed. This hole in the roof is a little back toward the cylinder from the crankshaft end of the engine.

The wreck was caused by a large tightener pulley breaking away from its mooring and bumping into the flywheel, knocking out a section of the rim, after which the entire wheel went to pieces.

A few minutes before the wreck the engineer's attention was called to this tightener by a noise, which was out of the ordinary, and when it left its place he was on the other side of the flywheel in the act of tightening it. While the flywheel was tearing itself to pieces the engineer closed the throttle.

The safety stop was broken, but the engine did not speed up perceptibly before steam was shut off. Other than the loss of the flywheel the engine did not suffer. The damage was estimated at $5000.

Standard Dimensions for Brass Flanges

On Sept. 17, 1913, the Committee of Manufacturers on Standardization of Fittings and Valves adopted the dimensions given in the accompanying tables as standard for brass flanges. These schedules are to be effective Jan. 1, 1914. With reference to the flanges the bolt holes are to be drilled $\frac{1}{16}$ in. greater than the bolt diameter for sizes 2 in. and smaller and $\frac{1}{8}$ in. greater for sizes 2½ in. and larger. The flanges are to have plain smooth faces, and when coupled with extra-heavy iron flanges, valves or fittings, the latter should have the raised surfaces faced off.

TABLE 1. STANDARD FLANGES FOR PRESSURES UP TO 125 LB.

Size In.	Dia. of Flange, In.	Thickness of Flange, In.	Bolt Circle, In.	No. of Bolts	Size of Bolts, In
¼ & ⅜	2½	7/16	1⅞	4	½
½	3	½	2⅜	4	½
¾	3½	9/16	2¾	4	½
1	4	⅝	3	4	½
1¼	4½	¾	3½	4	⅝
1½	5	13/16	3⅞	4	⅝
2	6	⅞	4¾	4	¾
2½	7	15/16	5½	4	¾
3	7½	1	6	4	¾
3½	8½	1 1/16	7	4	¾
4	9	1 1/16	7½	8	¾
4½	9½	1 3/16	7⅞	8	¾
5	10	1 3/16	8½	8	¾
6	11	1 3/16	9½	8	¾
7	12½	1 5/16	10½	8	¾
8	13½	1 5/16	11½	8	¾
9	15	1 7/16	13¼	12	¾
10	16	1 7/16	14¼	12	¾
12	19	1 9/16	17	12	⅞

TABLE 2. EXTRA-HEAVY FLANGES FOR PRESSURES UP TO 250 LB

Size In.	Dia. of Flange, In.	Thickness of Flange, In.	Bolt Circle, In.	No. of Bolts	Size of Bolts, In.
¼ & ⅜	3	½	2	4	½
½	3½	9/16	2⅜	4	⅝
¾	4	5/8	2¾	4	⅝
1	4½	¾	3¼	4	¾
1¼	5	13/16	3½	4	¾
1½	6	⅞	4½	4	¾
2	6½	15/16	5	4	¾
2½	7½	1 1/16	5⅞	4	¾
3	8¼	1 1/16	6⅝	8	¾
3½	9	1 3/16	7¼	8	¾
4	10	1 5/16	7⅞	8	¾
4½	10½	1 5/16	8½	8	¾
5	11	1 7/16	9¼	8	¾
6	12½	1	10⅝	12	¾
7	14	1 1/16	11⅞	12	⅞
8	15	1 1/8	13	12	1
9	16½	1 3/16	14	12	1
10	17½	1 5/16	15¼	16	1
12	20½	1 7/16	17¾	16	1⅛

❖

Tight Settings for Water-Tube Boilers*

The brickwork of every boiler should hold the heat. For that purpose, first, the passages for heat outward through the setting should be effectively restricted, and, second, there should be no cooling off of the hot gases by drawing large quantities of cold air into the flues.

This twofold purpose may be attained by making the setting thick enough, of material having little porosity to air—glazed brick, for example—with closest possible joints, these to be well filled and cracks in the masonry to be avoided.

The joints should not be more than $\frac{5}{16}$ in. wide outside and $\frac{3}{16}$ in. inside. With firebrick work the mortar used for filling should have the composition of the bricks. It is advisable, if at all possible, only to fill the joints after the setting has been in service for some time and is therefore perfectly dry.

The following are rules for avoiding cracks in the setting:

It is especially important to lay a good foundation. The boiler setting is to be treated like the masonry of a house and adequate foundations are particularly needed where the weight of the boiler is to be carried from the ground.

Further, the boiler setting must be well tied, which is especially true for the parts of the masonry around the fire hearth. It is proper to construct the ties as also carriers for the weight of the boiler and either to lay the boiler upon the ties or hang it therefrom.

The play needed for expansion must be given to the body of the boiler and no thrust against the setting must be permitted. Where parts of the boiler extend through the setting, some play should be allowed and the masonry at these places should be secured with iron framing. The resulting crevice is to be closed with asbestos wool, rope or sheets. Likewise, all openings required in the setting are to have iron framing and be well packed. Entrance openings are to be walled off behind the door to a thickness of half a brick and plastered with clay mortar.

No part of the masonry should rest on the boiler itself, but each should have its own support.

In the thick side walls it is advisable to leave insulation spaces from 2 to 4 in. wide, averaging about 3 in., thus dividing the brickwork into an inner and outer wall. Every five or six courses the two walls are connected by two superposed courses, but openings are left in them to unite the insulation spaces.

Where these bridging courses are inserted there are employed hoop-iron or woven-wire inserts, which in case of expansion by heat give the inner wall body a great freedom of movement with respect to the outer one, yet connect the two with adequate rigidity. Also, to prevent cracks, inserts of hoop-iron, etc., can be laid in the joints of the brickwork.

The inner wall should be made not less than 16 in. thick, so that for an open space 3 in. wide and an outer wall one brick thicker, the minimum wall thickness is 27 in.

If the foregoing rules are observed the setting will answer the requirements that were laid down at the start. The speaker gave also rules for protecting the masonry around the furnace and mentioned special packing material of different manufacturers. Also for packing and to a certain extent encasing the surface of the setting, there are used single and double coats of tar, oil-paint and water glass (potassium or sodium silicate). For filling the cracks that occur, there may be used loam and molasses, loam with infusorial earth, tar with infusorial earth, water-glass and loam with horse manure.

For packing the cracks that occur it has proved effective to use strips of linen fastened with broad-headed nails to the cracked places and spread with plaster of paris stirred in water.

If lack of room compels the use of thin outer walls, they can be effectively tightened and strengthened by covering with sheet-metal plates and filling the crevices.

❖

Elaborate plans are being laid down for the storage and handling of coal at the Panama Canal terminals. There will be two main coaling plants, one at Cristobal and the other at Balboa. The former is to be the larger and will have a capacity for 100,000 tons under-water storage as a reserve for naval use, 100,000 dry storage for canal use and 100,000 tons for emergency use. At the Balboa plant there will be capacity for 100,000 tons wet storage, 80,000 tons dry storage and 30,000 tons for emergency use.

*Abstract of a report by Chief-Engineer Pietzsch presented at the convention in Munich, of the International Association of Steam Boiler Inspection Societies; translated from "Glückauf."

Locomobiles on the Uniflow System

By Dr. Alfred Grademvitz

It will be remembered that in the uniflow engine, the flow of steam and accordingly the flow of heat is in the same direction. The steam enters at both ends of the cylinder and issues from its center, undergoing on its path no change in direction. The ends where the steam enters are accordingly never cooled by the escaping steam, thus eliminating a large source of loss obtained in ordinary steam engines. The single-cylinder Stumpf engine has a steam consumption as low as the best of compound engines, and besides the steam consumption remains practically constant within wide limits of load. A marked advantage of the Stumpf engine is its simplicity.

A firm of German builders, the Maschinenfabrik Badenia, of Weinheim, has, with others, been building a locomobile designed on the Stumpf system. In this locomobile, condensing is effected in an injector condenser, the vertical air pump of which is driven from a crank-pin mounted on the flywheel hub. The feed water is heated in a counterflow preheater. The boiler combined with the engine in a compact unit is equipped with removable tubes, which are arranged to give easy access for cleaning. The boiler shell and the superheated steam-supply pipe are thoroughly jacketed to prevent any appreciable loss from radiation. The boiler and superheater have been so proportioned that a superheat upward of 250 deg. F. is available at normal loads. The superheater is of the thin-flow type (on the Platz system) made up of tubes arranged in front of the boiler tubes and traversed by steam in a direction opposite to that of the gases. The superheater travels on rollers inside the casing, and is so arranged that the smoke may be discharged toward the top or downward.

In the case of large condensing engines, a preheater is used and encompasses the superheater, insuring a further utilization of the gases escaping from the superheater. This preheater consists of two systems of hemispherical tubes traversed by the boiler-feed water in a counterflow direction to the gases. These systems are connected with the feed-water pipe and with one another. The superheater has high efficiency in spite of a relatively small heating surface as the steam is distributed into such thin currents that the heat of the gases is readily absorbed.

Horizontal grate furnaces are used exclusively in the case of ordinary bituminous coal. An extra-large horizontal grate can be employed in connection with low grade coal or lignite, while stepped grates are found most suitable in the case of sawdust, and the like. Coal-fired boilers of more than 100 hp. are preferably equipped with automatic stokers. Apparatus for firing liquid fuel can also be provided.

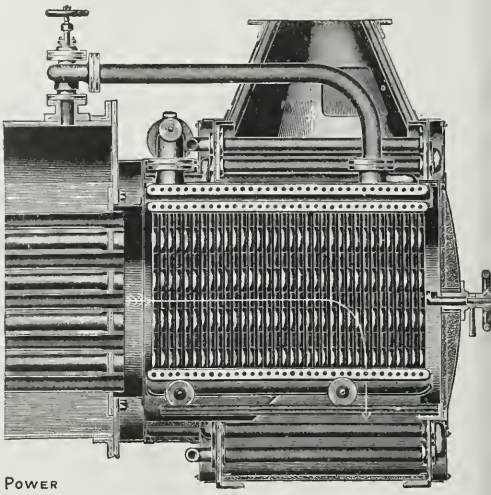
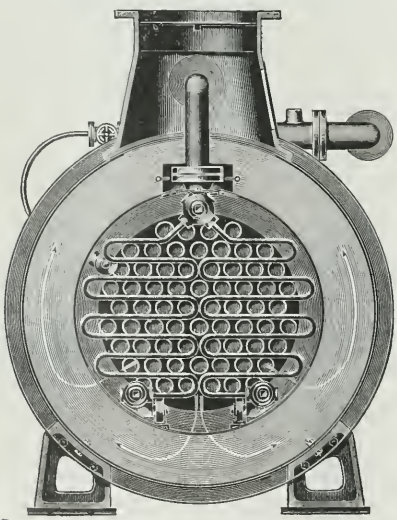


Fig. 2. Boiler Equipped with Both Superheater and Preheater



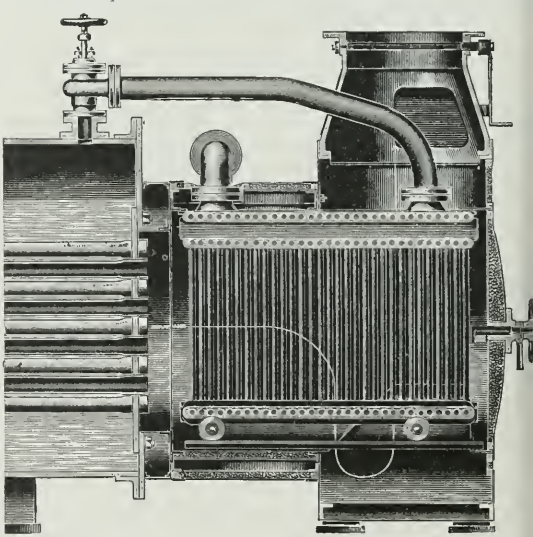
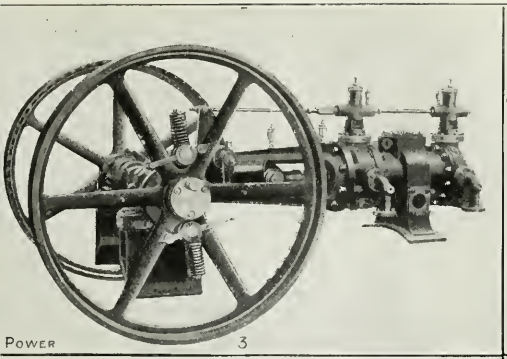
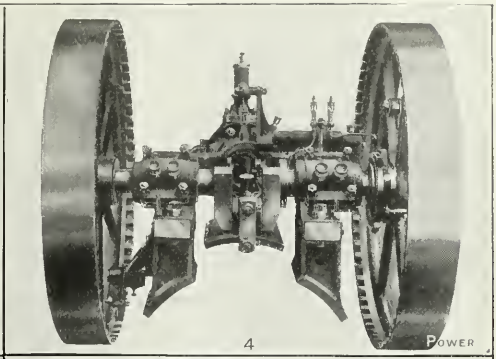
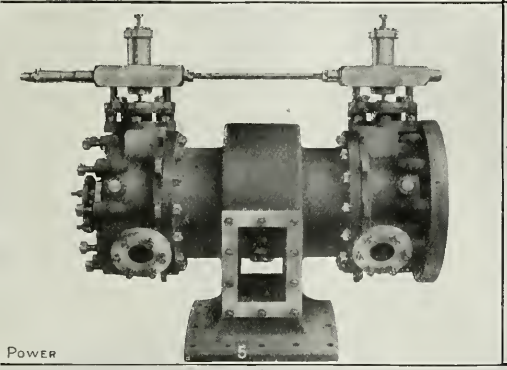
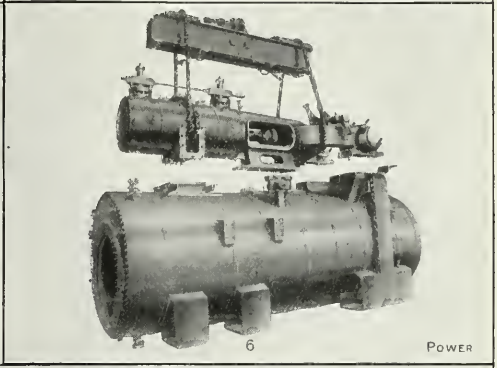


Fig. 1. Sectional Views of Boiler, Showing Superheater in Front of Tubes









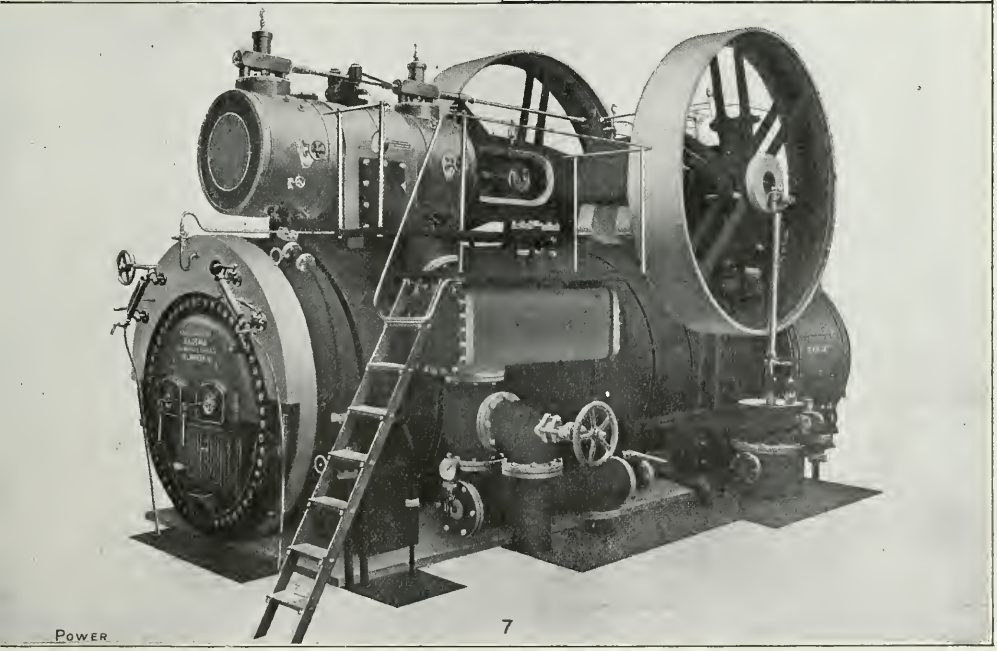


FIG. 3. THE ENGINE BEFORE BEING FITTED ON BOILER. FIG. 4. VIEW ACROSS CRANKSHAFT. FIG. 5. CYLINDER AND VALVE-GEAR. FIG. 6. ERECTING LOCOMOBILE. FIG. 7. LOCOMOBILE ASSEMBLED AND READY FOR ACTION

ELECTRICAL DEPARTMENT

Comparison of Lead-Sulphuric and Edison Types of Storage Battery

By Eugene Oster

The lead-acid battery, due to its priority, has been utilized in all applications where a storage battery can be used: its largest field is for power-house work. Owing to its high efficiency, it is improbable that its supremacy in this field will be endangered by any other type of battery, since a difference of a few per cent. in efficiency is usually the determining factor in the selection of a piece of power-plant apparatus.

The Edison battery, while originally intended to fill a need in automobile work, has recently extended its field of usefulness to include a great number of applications. It is now being used in self-contained car service, for propelling mine locomotives, for train lighting and for home lighting in isolated districts. Its largest field, however, has been in the commercial truck service, where light weight, fool-proof construction and simplicity of care render it well suited for traction and portable use and offset its slightly lower efficiency.

The advantages and disadvantages of the two types will be made more apparent by a detailed examination of their respective characteristics; the comparison here intended, including construction, care and management, efficiency, capacity, life and cost.

The Lead Cell

The lead-acid battery consists of two electrodes or sets of electrodes, the positive and negative, immersed in the electrolyte. The two electrodes are sponge lead (Pb), for the negative, and peroxide of lead (PbO_2), for the positive, the electrolyte being dilute sulphuric acid. The hard, velvety brown chocolate-colored positive, and the soft, light gray negative element, are very readily distinguishable.

Plates

Storage batteries of the ordinary lead-sulphuric type are divided into two general classes—the Planté and the Faure. The Planté type of plate is constructed of solid sheet lead so fashioned as to present a large area to the action of the electrolyte. The active material is formed on the plates, either electrically, by charging and discharging (commonly called "forming") or chemically.

In the Faure type the active material is applied mechanically to lead conducting plates or grids, and for this reason it is commonly called the "pasted" type. The positive plate is made of lead upon which a coating of peroxide of lead has been formed or mechanically applied. The negative plate is of pure lead with a spongy or porous surface, and the plain lead body of each plate serves as a support for the active material.

All the materials of the plates, the grids, spongy lead, lead peroxide, and lead sulphate, are practically insoluble in the sulphuric acid. The electro-chemical action which takes place in the cell slowly oxidizes the grids and causes them to disintegrate. The lead sulphate formed during discharge has a greater volume than either the spongy lead or the lead peroxide; consequently, there is expansion and contraction of the active material. The inability of designers to provide for this change of volume has been responsible for many troubles. Moreover, the lead peroxide of the positive plate is somewhat noncohesive, and during the subsequent gassing at the end of the charge some of it falls off, forming sediment, which if allowed to accumulate will short-circuit the plates. This loss of active material, unless compensated by the corrosion of the exposed lead surface to form new lead peroxide, results in a decrease in the capacity of the plate. The spongy lead of the negative plates being quite cohesive does not fall off if the cells are kept free from short-circuits and foreign materials, but it gradually becomes more compact and through the diminution of its porosity its capacity decreases. The rate of this decrease is greatest at the start and finally becomes very small. The negative plates are usually given sufficient initial capacity to provide for this shrinkage.

Separation and Insulation

In order to keep the plates apart and thus prevent short-circuits, rod or diaphragm separators are used in all batteries except those in which the plates are covered with hard rubber or celluloid envelopes. Where permanency is desired, the only permissible materials are hard rubber, glass and earthenware. Wood separators are extensively used, but must be replaced each time the cells are moved. Soft vulcanized rubber cannot be used for permanent work, due to its rapid disintegration in the acid.

Electrolyte

The electrolyte is sulphuric acid, diluted with sufficient pure, distilled water to bring it to the required density, the acid in every instance being poured into the water. The density varies with the condition of the battery and also has a very important bearing on its operation. If it be too high or too low, excessive sulphation is facilitated and the plates are liable to depreciate rapidly. The usual limits in practice are 1.170 to 1.195 when discharged and 1.190 to 1.225 when fully charged.

Containing Cell

Rubber and celluloid are used almost exclusively for traction and portable cells; glass is limited to stationary batteries. While the life of a storage battery is much longer when installed in glass jars, because it permits examination of the plates, the cost of the glass and its tendency to crack under temperature changes has caused it to be avoided in large sizes. Because of their high initial cost and short life, glazed earthenware containers have not come into extensive use. Wooden lead-lined tanks are very largely used for large station batteries, but are somewhat expensive.

Assembling and Installation

The individual plates are assembled to form a complete cell, by "burning" to a common lead bar or strip, all plates of like polarity. The cell terminals are then joined by means of bolts or by "burning." The former method is the more expedient, though open to the objections that the bolts must be frequently inspected to prevent loose connections and also that all connections must be protected from the acid spray by a coating of asphaltum or vaseline. The "burning" method requires the service of a skilled workman and special apparatus; hence is rather expensive, though permanent. It also renders the plates less capable of being disassembled for cleaning than does the bolt connection.

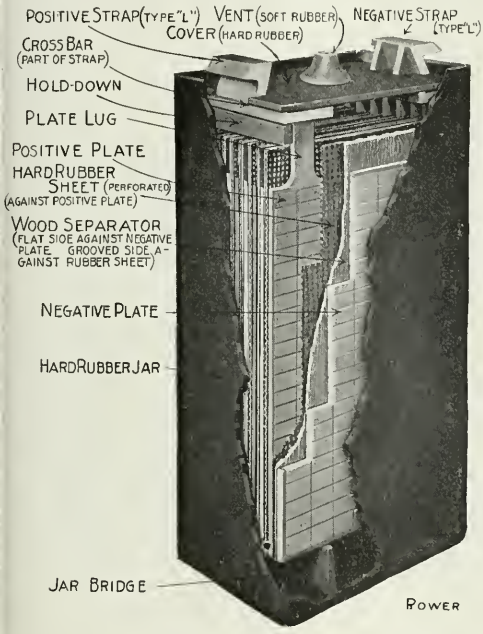


Fig. 1. Gould Cell Partly in Section

Batteries should be installed in especially prepared rooms, dry and arranged for maintaining a moderate temperature during cold weather. The room should be well ventilated and accessible, and the floor should be covered with asphalt, tile or vitrified brick, and should slope slightly toward numerous discharge drains. All metal work near the batteries must be lead covered, and any metal work subjected to acid fumes should be painted with acid-proof paint.

Care and Management

On continuous discharge the one-hour rate should usually not be exceeded, and this should last only a short time, say, 20 min., except in emergencies or in the case of regulating batteries. When discharging at the normal rate, the discharge should never be allowed to fall below a voltage of 1.75 volts per cell. At rapid rates the discharge may be carried down to 1.60 volts per cell. If the discharge be continued after these voltages are reached, the plates may be permanently injured.

The rate of charge may be rapid when the battery is nearly or quite exhausted, but should be low when nearing the end of the charge, that is, after gassing begins. The maximum charging rate should not be greater than the two-hour rate, when the eight-hour rate is normal. Thin plates allow a more rapid charge than thick.

Each of the cells of a battery should be tested with a voltmeter and a hydrometer once a week. Where the number of cells in a battery is large, frequent inspection of each cell is impracticable. Therefore, a cell which receives the same usage as the rest is selected to serve as an indicator, and is known as a "pilot cell." Daily readings of the voltmeter, hydrometer and thermometer should be taken from this cell.

Unless a battery is properly looked after, sulphation of the injurious kind is liable to set in with the resulting shedding of active material, buckling, loss of capacity, increase of internal resistance with consequent reduction of efficiency, and increase of temperature with passage of current.

Efficiency

The efficiency varies with the rate of charge and discharge. The shorter the cycle of charge and discharge, the higher is the efficiency. Under usual conditions, the watt-hour efficiency of a battery used for storage only; that is, fully charged and subsequently fully discharged; is from 70 to 80 per cent. The larger the battery, and the higher the voltage at the end of discharge, the greater will be the efficiency. With large batteries, in which the charge is never continued very long after gassing begins and discharge is stopped at about 1.87 volts, the efficiency of storage cells may be as high as 85 per cent. A fair commercial figure is 80 per cent. for storage and 92 per cent. for regulation batteries.

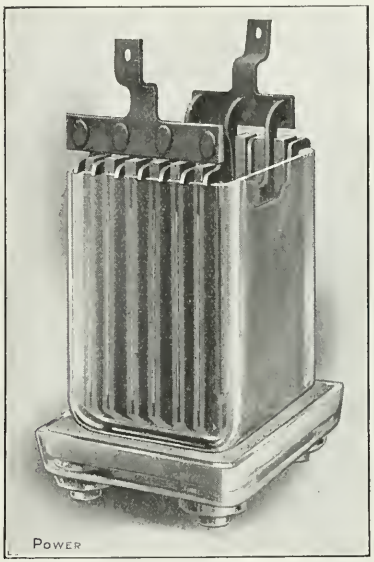


Fig. 2. Gould Battery with Glass Jar and Sand Tray

Capacity

The term "capacity" is to be understood as referring to the amount of energy in ampere-hours which may be taken out of a cell from the beginning of discharge until the voltage has decreased to 1.80 volts, when the battery is supplying current at the eight-hour rate, or to 1.68

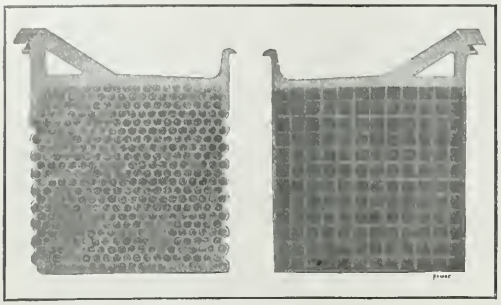


Fig. 3. "Chloride" Positive and Negative (Box Type) Plates—Electric Storage Battery Co.

volts when working at the one-hour rate, and at a temperature of 70 deg. F.

The output of a lead cell decreases with increase of discharge rate, increase of time and decrease of temperature. A loss of storage capacity may arise from loss of active material from the grid, loss of electrolyte, formation of a layer of sulphate between the grid and the active material, or from closing of the pores of the plates by impurities, sulphation or contraction.

Life

The life of a storage cell depends largely upon how closely it is worked to its rated capacity and upon its mechanical construction. High rates of charge and discharge, high working temperature, vibration, entrance of impurities into the cell, and lack of correct attention have a marked detrimental effect. The life of a pasted plate is shorter than that of the Planté type, while the life of a negative plate of either kind is from two to five times that of a positive plate of the same kind. Planté positive plates have a total life of about 1200 discharges at the eight-hour rate.

Edison Type

The basic idea of Edison's work appears to have been the elimination of sulphuric acid and the substitution of a mechanically strong material for lead. The first result of his efforts was an alkaline-cadmium-copper oxide cell, which was withdrawn from the market in 1901. After six more years of persistent investigation, he brought out the present nickel-iron-alkaline cell.

Plates

The positive plate consists of heavily nickel-plated, perforated steel tubes, arranged in rows and filled with alternate layers of nickel hydroxide and exceedingly thin flakes of pure nickel. The materials are fed in such quantities as to make layers approximately 0.01 in. in thickness for the nickel hydrate and less for the nickel flake. The tube, after being filled with active material, is reinforced with seamless steel rings, which prevent it from expanding away from and breaking contact with the contents. The tubes, after being crimped and flattened at both ends, are clamped into perfect contact with a steel frame or grid, made of cold-rolled steel and heavily nickel-plated.

The negative plate consists of a grid of nickel-plated, cold-rolled steel, holding a number of rectangular pockets filled with powdered iron oxide.

The perforated container construction prevents loss of active material by disintegration, thus doing away with sediment, internal short-circuits, and the necessity of cell washing. Moreover, the steel-nickel construction of the plates makes "buckling" impossible; even a dead short-circuit of the terminals will not affect the condition of the plates. The materials composing the plates are immune from attack by the electrolyte and thus their permanency is assured.

Separation and Insulation

The plates are separated by narrow strips of specially treated hard rubber. These strips correspond to the wood and rubber separators used in lead batteries, but unlike them are not injured by the electrolyte and need never be renewed. The end insulator is provided with grooves that take the edges of the plates, spacing them and insulating them from the steel container. At the sides of the cell, between the outside negative plates and the container, are inserted smooth sheets of hard rubber. At the bottom, the elements rest upon a hard-rubber rack or bridge, insulating the plate from the bottom of the container. The plates of the positive and negative groups are respectively fastened by nuts to horizontal steel rods integral with the positive and negative terminal pieces and distanced by steel washers.

Electrolyte

The electrolyte consists of a 21 per cent. solution of potassium hydroxide in distilled water, with a small percentage of lithium hydroxide, having a normal specific

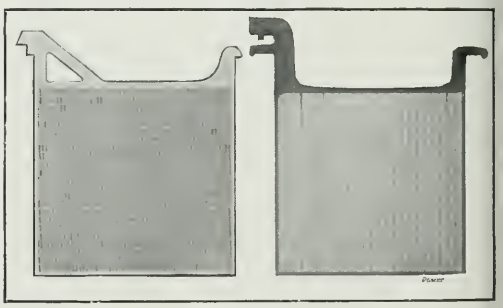


Fig. 4. "Tudor" Positive and Negative (Pasted) Plates—Electric Storage Battery Co.

gravity of about 1.200. The lithium hydroxide seems to accomplish a cementation of the positive material. In the early type where caustic potash was used alone, the positive plates deteriorated very rapidly, but when the action of the lithium hydroxide was discovered and applied, this deterioration was overcome. The electrolyte does not vary in density during charge and discharge, nor is the capacity of the battery affected materially by slight variations. In mixing the electrolyte, no special care need be exercised in order to prevent injury to the

operator, and the potash solution does not attack the steel.

Containing Cell

The rectangular container is made from cold-rolled, corrugated, nickel-plated sheet steel, welded at the seams by the autogenous method, making leakage or breakage from severe vibration impossible. The nickel protection

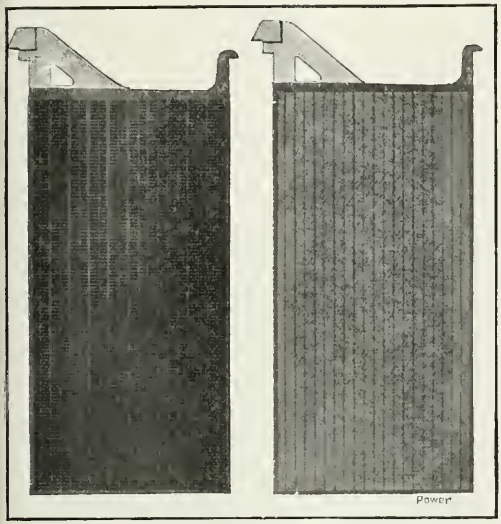


Fig. 5. Positive and Negative "Exide" Plates —Electric Storage Battery Co.

is supplemented by dipping the container in a compound which gives it a tough, yet flexible insulating coating. The cover or top is nickeled steel and is welded to the rest of the can after all parts have been assembled therein.

The cover of the early type of can had four mountings. Two of these openings were for the polepieces, a third for the separator valve, which permits the escape of gas when charging, but prevents spraying, evaporation, the spilling of the electrolyte and the entrance of impurities. The fourth opening was for the purpose of adding water to replace that carried off in charging, and was fitted with a cover that could be clamped down and made water-tight by a locking lever. The present form of cell has the separator valve inside of the filling aperture, so that there are only three perforations in the can cover.

Assembling and Mounting

The cells are assembled into a battery in strong side-suspension trays, the cells rest upon and are held firmly in place by means of steel supports known as "cradles" and "hold-downs." The weight of an Edison battery being about half that of a lead battery of the same capacity, and the former occupying a slightly smaller space, a lighter construction can be used in a battery room for the former than the latter. The Edison battery requires no fan-ventilated isolated room as no corrosive fumes are generated. The life of the containers depends upon their state of cleanliness, and if neglected they will corrode sooner or later.

The cells are electrically connected by nickel-plated copper links, swedged into lugs, which fit the tapered steel cell terminals. The lugs are drawn down and held to a tight fit by means of nickeled steel nuts, which screw on the ends of the terminals. To facilitate disconnecting, a screw jack is used to separate the lugs from the taper terminals to which they practically "freeze." Any person can connect up the cells and no skilled laborer, such as a "lead burner," is needed.

Care and Management

The care required by the Edison cell is limited to such matters as the addition of distilled water to make up for charging loss, the renewal of the electrolyte when its specific gravity is below 1.16 after a full charge, the keeping of the outside of the battery clean, and the occasional recoating of the trays with an alkali-proof paint.

It is permissible, for short periods, to discharge at any rate desired; but maximum power is developed when the current is about six times normal. Continuous discharge should not exceed 25 per cent. above normal rate. Short-circuits subject the cell to severe strains, but no injury results if the short-circuits are not consecutive and often repeated.

The ability of the Edison cell to stand short-circuits is due to its high internal resistance. The short-circuit current for the alkaline type of battery is about sixteen

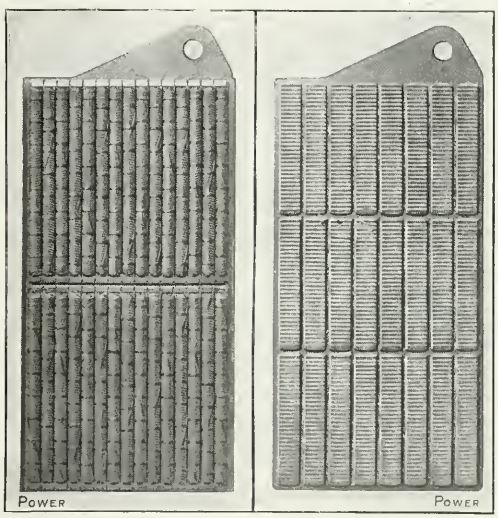


Fig. 6. Positive and Negative Plates— Edison Battery

times its normal discharge current, while that for the acid-lead type is about fifty times its normal discharge current.

Charging should never be done at less than the normal seven-hour rate, and may be boosted to high rates for brief periods so long as the temperature of the cell does not rise above 115 deg. The Edison cell can be recharged at any time, without injury, regardless of the extent of the former charge remaining. Moreover, no damage is done by long and oft-repeated overcharging. The only thing necessary when taking a cell out of commission is to

fill the cell with distilled water to ½ in. above the plates. When putting the battery in commission, the plates should be covered with electrolyte and the cell charged for 12 hr. at normal rate, after which the cell may be treated as usual. Cells have had their electrolyte boiled away and have stood empty for weeks without being injured. They regained their full capacity after being charged and discharged once. The effect of charging in a reversed direction for 15 hr. at the eight-hour rate was remedied after having subjected the cell to four cycles of charging and discharging in the normal direction.

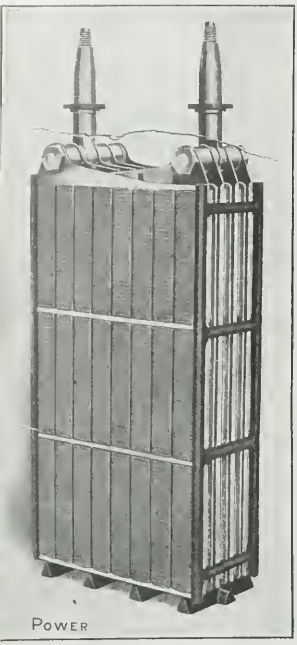


FIG. 7. ASSEMBLED PLATES OF EDISON BATTERY REMOVED FROM CONTAINER

EFFICIENCY

The efficiency of the Edison battery is lower than that of the lead cell and is necessarily so on account of the low electromotive force, about two-thirds that of the lead battery. The efficiency is much increased by partial charging as compared with normal charging. On short charges the efficiency is 95 per cent. for ampere-hours and 75 per cent. for watt-hours, while on seven-hour charges this falls to 82 per cent. for ampere-hours and 58 per cent. for watt-hours. The volt efficiency is about 72 per cent. for the usual charge. The efficiency of the Edison cell in contrast to that of the lead cell increases with use.

CAPACITY

The capacity of an Edison cell increases with use and it is guaranteed to give its full capacity for four years. The capacity of the cell varies from 13.5 to 17 watt-hours per pound of material and from 0.65 to 0.75 watt-hours per cubic inch of complete cell volume.

LIFE

Owing to the comparatively recent development of the Edison cell its ultimate life is not known definitely. Batteries, which are being tested for life under purposely imposed conditions designed to shorten their life, have developed over 1200 complete cycles of charge and discharge, and still show a capacity about 10 per cent. above their normal rating. The life of a cell is shortened by continuous working at high temperatures and high current rates, but the occasional subjection to these treatments is said to have no detrimental effect.

COST

The first cost of an Edison cell is more than that of a lead cell of equal capacity; the list price of a complete single cell being from 6 to 9c. per ampere-hour of capacity. When durability and small maintenance cost are considered, however, this difference is compensated.

CONCLUSIONS

The relative advantages and disadvantages of the two types of cell may be summarized as follows:

(1) The principal advantage of the lead cell lies in its high efficiency and low first cost.

(2) Among the innate disadvantages of the sulphuric-acid battery can be mentioned: Excessive weight; structural weakness of parts; corrosive nature of electrolyte and fumes; loss of capacity; shedding of active material; exacting and incessant care required for successful operation; fracture and buckling of plates; sulphation; internal discharge; high installation and maintenance costs.

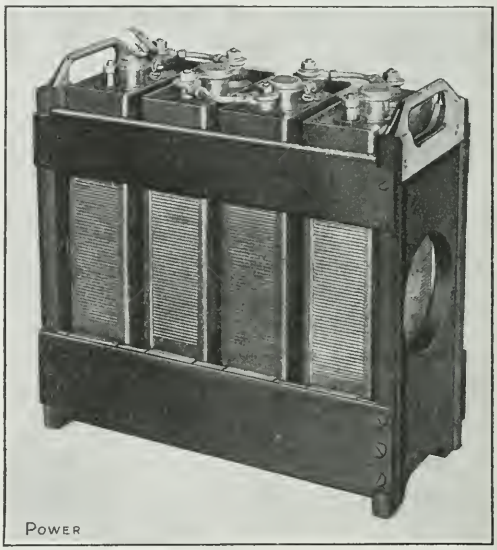


FIG. 8. ASSEMBLED CELLS IN BATTERY TRAY—EDISON TYPE

(3) The advantages of the Edison cell are: Increase of capacity with use; simplicity of the care required; ease of interconnecting the cells; steel-preserving electrolyte and lack of corrosive fumes; durability and sturdiness of cell structure; low weight per unit of capacity; ability to withstand short-circuits; absence of sulphation, buckling and sediment; immunity from injurious effects of overcharge; low maintenance cost.

(4) The disadvantages of the Edison cell may be summed up as high initial cost and comparatively low efficiency, due to low cell voltage.

It is thus evident that each type of battery has its special field, and, hence, a satisfactory selection can be made only after an exhaustive investigation of all the factors entering into an installation.

HEATING AND VENTILATION

Cost of Heating and Power-Plant Apparatus

By W. J. Downing

Several years ago the writer became convinced that the only way to obtain cost figures was to keep an accurate account of the costs of the various items in plants which came to his attention and then to work out these costs on a unit basis.

In order that engineers and owners may form an opinion as to the probable cost of a proposed system the following information is submitted: List prices of material are usually available and when possible discounts are given for standard apparatus. All prices are based on actual installations, most of them in the New England States, and allowance should be made for other localities, based on the difference in cost of labor and material.

Radiation

Radiation will be classified under five headings:

1. Cast-iron direct radiators cost 19 to 27c. per square foot of surface, depending on the height of the radiator. The labor cost will be nearly the same for casting and finishing a section containing 1 sq.ft. of surface as for a section containing 5 sq.ft.

2. Cast-iron indirect radiators of the pin type for gravity work cost 16 to 18c. per square foot.

3. Cast-iron radiators for fan systems cost 25c. per square foot.

4. Pipe coils for direct radiation cost 30c. per square foot.

5. Pipe heaters consisting of 1-in. pipes with cast-iron bases for fan systems cost 45 to 50c. per square foot of surface. For cast-iron bases with a damper for direct indirect radiators add $1.25 for each 10-in. length of base.

The labor cost for installing direct radiators on a one-pipe system can be obtained by allowing one day's time for a steam fitter and his helper for each radiator. This covers the time required to run the vertical risers and connect and set the radiators. It does not include the time required to place the horizontal mains in the basement and connect up the boilers. This item will be covered under another heading. For a two-pipe system allow 1½ days time for a fitter and helper per radiator.

Indirect radiators for gravity and fan-blast systems cost about ½c. per pound for the former and 1c. per pound for the latter for erection together with the labor cost of a fitter and helper for one day for each four connections made to the heater sections.

Allow 2½ to 3c. per square foot of surface of pipes and radiators for bronzing.

Automatic air valves cost 75c. to $1 each in place.

For temporary setting of direct radiators used to furnish heat in the building while under construction, allow $2.25 for each radiator.

Figures based on a large number of installations show that an allowance of $50 per thermostat should be made for automatic control. This includes the air piping, compressor dampers and thermostats, set in place and connected.

Boilers and Auxiliaries

Small cast-iron fire-pot boilers for house heating cost $30 to $35 per square foot of grate area.

Cast-iron sectional boilers for house and public-building heating cost $21 to $25 per square foot of grate area.

Horizontal fire-tube boilers set in place complete with trimmings ready for steam and water connections cost $12 per horsepower.

The Manning type of vertical boiler for power-plant work will cost $10 per horsepower erected.

Water-tube boilers set in place with trimmings cost $14 to $16 per horsepower.

Internally fired boilers of the Morrison type cost $16 to $18 per horsepower, including trimmings.

Dutch or extended ovens are often used in power plants for burning a low grade of fuel, or utilizing the waste material from manufactured products. These ovens will cost $250 for a 300-hp. unit.

Superheaters cost $2.25 to $3 per horsepower, depending on the size and and type.

Special boiler settings designed to economize heat, similar to the Smith setting cost about $150 per boiler.

All of the above prices are based on boilers with plain grates. Shaking grates should be figured at from $5 to $6 per square foot of surface.

Feed-water heaters of the closed type cost from 75c. to $1 per horsepower, depending on the size of the unit. Feed-water heaters and purifiers of the open type cost $2.20 per horsepower for a 100-hp. unit and $1 per horsepower for a 1000-hp. unit. Intermediate sizes cost a proportional amount.

A good damper regulator for controlling the draft in boilers can be obtained for $50.

Boiler-feed pumps cost 50c. per horsepower capacity of units of 150 to 200 hp.

Blowoff and return tanks suitable for 100 lb. pressure cost about 8c. per pound in weight.

Copper hot-water tanks good for 100 lb. pressure complete with steam coil cost about $1 per gallon capacity. Add $50 if the tank has automatic control.

Steam traps take a discount of 40 per cent. from list prices.

Pipe Fittings and Valves

While there are several large manufacturers of these products it is usually safe to figure the following discounts: Steam pipe, 75 per cent.; valves, 50 to 60 per cent.; cast-iron fittings, 70 per cent.; spiral-riveted pipe, 70 per cent.

An accurate list should be made of the actual material required for any particular installation, as there are

too many variables to use a unit price per horsepower capacity of the plant. The labor cost will average $1.50 per horsepower for connecting the boilers and installing the basement mains in plants of 200 to 400 hp.

The special valves necessary for a first-class vacuum system cost $6 to $8 per radiator. Another method of figuring vacuum systems is to allow 10c. per square foot of radiation for the special apparatus required.

Covering

An asbestos covering 4 in. thick for boilers and heaters will cost in place 50 to 60c. per square foot of surface. Air-cell covering 1 in. thick will cost 22c. per square foot. Eighty-five per cent. magnesia 1 in. thick will cost 30c. per square foot. These prices include the labor required to apply and are useful in calculating the cost of covering heating ducts and smoke flues.

Steam-pipe covering made of 85 per cent. magnesia will cost one-half of the list price, including the labor of applying. If desired the discounts applying to the various types of covering can be obtained and the labor cost based on the fact that one man will cover 100 ft. of straight pipe per day up to 4-in. diameter or will cover 40 fittings per day up to 4-in. size. The above amounts will be more for larger sizes due to the increased labor of handling.

Ventilating Apparatus

Centrifugal steel-plate fans for ordinary systems in which the total pressure does not exceed ¾ oz. will cost $10 to $13 per 1000 cu.ft. of air per min. capacity, depending on the size.

Direct-current motors for driving fans will cost $18 to $25 per horsepower. Regulating rheostats cost 60 per cent. of the list prices.

High-pressure engines for fan driving cost $10 to $16 per horsepower. Low-pressure engines for fan driving cost $18 to $22 per horsepower.

Air washers are usually based on a velocity of 500 ft. per min. and on that basis cost $18 to $26 per 1000 cu.ft. of air per min. capacity. Erection of fans, motors and air washers will cost about 1c. per pound in weight.

Galvanized-Iron and Steel-Plate Work

Piping arrangements employing galvanized-iron distributing ducts cost about 15c. per pound in place. The ratio of weight of iron to the cubic contents of the building varies widely with different types of building. In factory work where heating is the primary object the galvanized-iron ducts for an overhead system will average 1 lb. of iron to 100 to 125 cu.ft. of contents. In buildings where ventilation is the main object no standard values can be given as the amount of metal will depend on the standard of ventilation maintained. In each case the actual weight of metal must be calculated from the plans.

Steel-plate work for smoke flues costs from 6 to 8c. per pound.

Registers and Screens

Cast-iron registers for floors and side walls cost one-fourth the list price. Bronze registers cost one-half the list price. Plain wire screens with angle- or channel-iron borders cost 15 to 25c. per square foot. Allow 3c. per square foot for bronzing.

Filter screens of cheese cloth for removing dust from the air are based on a velocity of 30 to 50 ft. per min. through the net area. Their cost will be from 50 to 70c. per square foot, depending on the quality of material. Mushroom ventilators cost 65 to 75c. each.

Foundations

Allow 75c. per cubic yard for excavation in ordinary soil and $4 per cubic yard for rock. Brick foundation walls cost 40 to 50c. per cubic foot in place. Concrete foundations cost $6 to $7 per cubic yard for the concrete and 15c. per square foot of surface for the forms. Waterproofing will cost 40c. per square foot.

Sprinkler Systems

Sprinkler systems cost from $3 to $3.25 per head, including pipe, sprinkler heads and erection. Hose racks for fire protection in public buildings cost $50 each, including piping and erection.

Gas Piping

In fireproof buildings gas-pipe systems cost $5 to $6 per outlet for labor and material. For residences of the usual frame construction allow $2.50 to $3 per outlet.

Electric Lighting

Labor and material for wiring will cost about $6 per outlet. Three-light office fixtures will cost $7 each, two-light brackets $6, and one-light brackets $4. These prices are for a good, substantial fixture hung and connected.

Unit Costs

While the conditions of various installations make it impossible to give a unit price for a system that will apply in all cases the average of a large number of jobs shows some interesting results. The average cost of a heating system for dwelling houses, using direct-steam radiation is 80c. per square foot of radiation. For office and factory work allow $1 per square foot of radiation. For hot-water direct radiation allow $1.25 per square foot of radiation. To these prices should be added that of the boilers to obtain the cost of the entire system.

Although the size of direct-steam radiators varies over a wide range the cost of complete systems, exclusive of boilers, averages $37 per radiator.

All prices stated in this article are the costs to the contractor. An allowance for contractors' profit should be added to the total cost of the system. Profit is usually figured as a percentage of the total cost and will vary from 10 to 15 per cent. It will be noticed that the prices stated above give a considerable range and the question may arise as to the exact value to be used. It may be helpful to note that in any case a price should be selected depending on the size of the apparatus. For instance, a boiler with 5 sq.ft. of grate area will cost more per square foot than one with 20 sq.ft. By paying attention to the relative size of the unit in question a fair estimate can be made of the cost from the values given.

❖

A 50,000-Hp. Hydro-Electric Plant is planned to be built at Montague City, Mass., by the Turner Falls Power Co. The initial development will total 30,000 hp. and is to be completed early in 1915. The plant will cover half an acre of ground and will utilize water from a canal 1.5 miles in length, requiring the excavation of 500,000 cu.yd. of material, of which 100,000 cu.yd. will be rock excavation from a ledge 30 to 50 ft. deep.

Shunt System of Connecting Radiators

By H. A. Kieselbach

In the Oct. 7 issue, Ira N. Evans, in his calculations for the flow of water through the shunt connection illustrated in Fig. 1, makes the following statement which appears at the top of page 508: "The length of the three 1½-in. pipes in the coil in terms of 1¼-in. pipe is proportional to the areas, that is, the greater the area the shorter the length to be equivalent as far as friction is concerned." From this he finds that by multiplying the lengths of the three 1½-in. pipes, *X*, *Y* and *Z*, in Fig. 1, by the area of a 1¼-in. pipe and dividing by the combined areas of the three 1½-in. pipes, an equivalent length of 7.353 ft. of 1¼-in. pipe is obtained. Or, in other words,

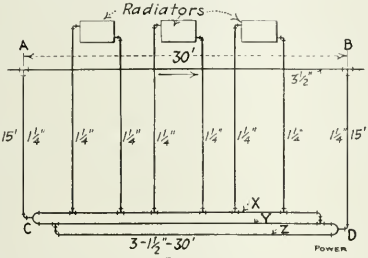


Fig. 1

the friction loss from *C* to *D* is equal to that caused by 7.353 ft. of 1¼-in. pipe and the friction of the entire shunt from *A* to *B* is equivalent to that of 37.353 ft. of 1¼-in. pipe.

The above assumption regarding equivalent lengths with respect to friction (which, by the way, does apply to electric conductors—the resistance being inversely proportional to their sectional areas) is not correct in connection with the flow of fluids through pipes, as it only takes into account the velocity of flow, which is inversely proportional to the pipe areas. The friction equation must also include the factor $\frac{V^x}{D^y}$. Take, for example, two pipes whose inside diameters are equal to D and D_1. The ratio of their sectional areas is

$$\frac{A}{A_1} = \frac{D^2}{D_1^2}$$

The ratio of velocities through these pipes when delivering equal quantities of water in unit time is

$$\frac{V}{V_1} = \frac{D_1^2}{D^2}$$

and their frictional resistances per unit of length are in the ratio of

$$\frac{F}{F_1} = \frac{\frac{V^x}{D^y}}{\frac{V_1^x}{D_1^y}} = \frac{\frac{\left(\frac{1}{D^2}\right)^x}{D^y}}{\frac{\left(\frac{1}{D_1^2}\right)^x}{D_1^y}} = \frac{\frac{D^{-2x}}{D^y}}{\frac{D_1^{-2x}}{D_1^y}} = \frac{D^{-2x}}{D_1^{-2x}} \times \frac{D^{-y}}{D_1^{-y}} = \frac{D_1^{2x+y}}{D^{2x+y}}$$

Substituting 1.85 for x and 1.166 for y

$$\frac{F}{F_1} = \frac{D_1^{2 \times 1.85 + 1.166}}{D^{2 \times 1.85 + 1.166}} = \frac{D_1^{4.866}}{D^{4.866}}$$

or the frictions of two pipes of the same length passing the same quantity of water in the same unit of time are inversely proportional to the 4.866 power of their diameters.

To prove these figures, refer to Fig. 2, in which a 1¼-in. pipe 30 ft. long is connected in series with a 1½-in. pipe of the same length. The quantity of water flowing through them is such that the velocity in the 1¼-in. pipe is 4 ft. per sec. The area of the 1¼-in. pipe is 1.5 sq.in. and that of the 1½-in. pipe is 2.04 sq.in. Therefore, the rate of flow in the 1½-in. pipe will be

$$4 \times \frac{1.5}{2.04} = 2.94 \text{ ft. per sec.}$$

Using the formula

$$h = l \times 0.00037 \frac{V^{1.85}}{D^{1.166}}$$

in which

h = Friction loss in feet;
l = Length of pipe in feet;
V = Velocity of flow in feet per second;
D = Internal diameter of pipe in feet.

We find the frictions of the two pipes to be as follows: For the 1¼-in. pipe,

$$h = 30 \times 0.00037 \times \frac{4^{1.85}}{0.115^{1.166}} = 1.796 \text{ ft.}$$

For the 1½-in. pipe,

$$h = 30 \times 0.00037 \times \frac{2.94^{1.85}}{0.134^{1.166}} = 0.8503 \text{ ft.}$$

Now comparing these friction heads, it will be found that the loss of head in the 1¼-in. pipe bears a ratio to that in the 1½-in. pipe of

$$\frac{1.796}{0.8503} = 2.112$$

or the loss of head in the 1¼-in. pipe is 2.112 times that in the 1½-in. pipe with equal quantity of flow.

The internal diameter of the 1¼-in. pipe is 1.38 in.

Fig. 2

and that of the 1½-in. pipe is 1.61 in. Substituting these diameters in the equation:

$$\frac{\text{Friction of 1¼-in. pipe}}{\text{Friction of 1½-in. pipe}} = \frac{1.61^{4.866}}{1.38^{4.866}} = 2.117$$

This result checks with the figure 2.112, derived from the actual calculations for the friction losses to the third figure, which is as close as possible with the values of the pipe diameters and areas used in deriving the results.

Having found that the frictions of two pipes are inversely proportional to the 4.866 power of this diameter, it also follows that the lineal feet of pipe required for a given friction under a given quantity of flow will be directly proportional to the 4.866 power of the diameter.

For example, in Fig. 2 the lineal feet of 1½-in. pipe equivalent in friction to 30 ft. of 1¼-in. pipe will be

$$30 \times \frac{1.61^{4.866}}{1.38^{4.866}} = 30 \times 2.117 = 63.51 \text{ ft.}$$

and the equivalent of 30 ft. of 1½-in. pipe in terms of 1¼-in. pipe will be

$$30 \times \frac{1.38^{4.866}}{1.61^{4.866}} = 30 \times \frac{1}{2.117} = 14.17 \text{ ft.}$$

The friction from A to B in terms of 1½-in. pipe will be

$$30 + 63.51 = 93.51 \text{ ft.}$$

and in terms of 1¼-in. pipe

$$30 + 14.17 = 44.17 \text{ ft.}$$

According to the rule given by Mr. Evans, the friction from A to B in terms of 1¼-in. pipe would be 52.06 ft., giving a value of the 1½-in. pipe in terms of 1¼-in. pipe about 50 per cent. too high.

The reason Mr. Evans' values of friction in the main and the shunt check the velocities derived by direct calculation is that the factor 37.353 ft. for equivalent length of shunt is used both in the calculation and the check, thereby introducing the same error in each.

In Fig. 1, assume that each of the 1½-in. pipes carries one-third the quantity of water passing through the 1¼-in. branches to the main. Strictly speaking, this is not true, but will answer for the present case.

To determine the length of 1¼-in. pipe equivalent to the three 1½-in. pipes, imagine first that two of the 1½-in. pipes, X and Y, are cut out of the circuit so that the remaining pipe Z will carry the full flow. From previous calculations we find that the resistance of Z will be equal to 14.17 ft. of 1¼-in. pipe. Now connect X and Y into the circuit and the velocity of flow in X, Y and Z becomes one-third of that which existed in Z alone and the friction through X, Y and Z falls to $(\frac{1}{3})^{1.85}$ of its original value in Z and the equivalent length of the three pipes in terms of 1¼-in. pipe becomes

$$14.17 \times \frac{1}{3^{1.85}} = \frac{14.17}{7.633} = 1.86 \text{ ft.}$$

On the basis of sectional areas, the equivalent length of 1¼-in. pipe is 7.353 or 400 per cent. too high.

Adding the equivalent of the three 1½-in. pipes to the actual length of 1¼-in. pipe in the shunt, we have

$$1.86 + 30 = 31.86 \text{ ft.}$$

which is the equivalent length of the entire shunt (neglecting the effect of fittings, valves, etc.) in terms of 1¼-in. pipe.

The equivalent of 31.86 ft. of 1¼-in. pipe in terms of 3½-in. pipe is

$$31.86 \times \frac{3.548^{4.866}}{1.38^{4.866}} = 3153.57 \text{ ft.}$$

Let

Q = Volume of flow through the shunt;

Q_1 = Volume of flow through the shunted portion of the 3½-in. main;

h = Loss of head from A to B—equal for both main and shunt;

K = A factor.

$$Kh = 30 \times Q_1^{1.85} = 3153.57 \times Q^{1.85}$$

$$Q_1^{1.85} = 105.12 \times Q^{1.85}$$

$$Q_1 = 12.382\ Q$$

or the volume of flow in the shunted portion of the main will be 12.382 times that in the shunt.

Taking Mr. Evans' value of 6 ft. per sec. as the velocity of flow in the main outside of the shunt, we have

$$6 \times 3600 \times 0.0687 \times 60 = 89{,}035 \text{ lb. per hr.}$$

as the quantity of flow in the 3½-in. main outside of the shunt. The flow in the shunt will, therefore, be

$$89{,}035 \times \frac{1}{12.382 + 1} = \frac{89{,}035}{13.382} = 6653 \text{ lb. per hr.}$$

with a velocity in the 1¼-in. pipe of

$$\frac{6653}{3600 \times 0.01039 \times 60} = 2.965 \text{ ft. per sec.}$$

The velocity of flow in the shunted section of the 3½-in. main will be

$$6 \times \frac{89{,}035 - 6653}{89{,}035} = 5.55 \text{ ft. per sec.}$$

Checking these results it will be found that the friction of 30 ft. of 3½-in. pipe with a velocity of 5.55 ft. per sec. is

$$30 \times 0.00037 \times \frac{5.55^{1.85}}{0.296^{1.166}} = 1.098 \text{ ft.}$$

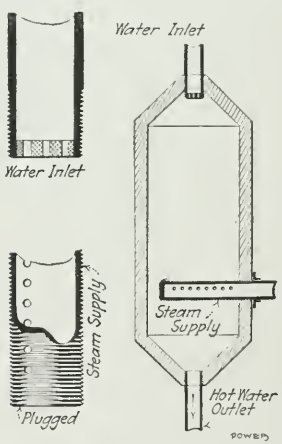
In the shunt, the friction of 31.86 ft. equivalent length of 1¼-in. pipe with a velocity of 2.965 ft. per sec. is

$$31.86 \times 0.00037 \times \frac{2.965^{1.85}}{0.115^{1.166}} = 1.096 \text{ ft.}$$

::

Hot-Water-Heater Trouble

A few years ago I made a small water heater like the one L. N. Webster described in the issue of Sept. 9, and had the same trouble with water-hammer. This hammer is caused by the water level being above the steam inlet, causing excessive boiling. This I remedied by plug-



Overcoming Water-Hammer in Heater

ging the water inlet with babbitt metal and drilling it full of ⅛-in. holes, making a spray. I also extended the steam-supply pipe through to the other side of the heater and drilled a row of ⅛-in. holes on each side. I opened the hot-water outlet wide and regulated the supply by the cold-water valve. This did away with all vibration and gave me a good supply of hot water.

C. R. Van Keuren.

Famoso, Calif.

EDITORIALS

Riveted Piston Rods

To their credit designers and constructors usually allow a liberal factor of safety for parts of engines and boilers that are obviously subject to great stresses, especially where there is doubt of the efficiency of the design. Very ordinary experience should inform a constructor that cold riveting of metals is severe abuse very likely to start their disintegration. Yet many reputable engine manufacturers, for no better object than economy of time and material, depend on this crude method of securing engine piston rods to pistons of considerable size. The form and strength of riveting of a piston rod are not open to ordinary inspection and have to be taken largely on faith.

A failure of a piston-rod riveting is described on page 735 of this issue. It appears that the rod end was flanged so thin that the "mushy" texture which riveting had imparted to the metal permitted the riveted end to be drawn out into cup form, resulting in the release of the hold of the piston rod.

The incident brings strongly to mind the question whether disintegration due to cold riveting is not so likely to result in failure that the practice should be abandoned for this important detail of engine construction. Failures of this kind have doubtless resulted in serious accidents that have been attributed to unknown causes or to the negligence of operating engineers, when in fact they have been due to imperfection of material, workmanship or design beyond possibility of his inspection.

Fixing the Blame

"Who was to blame?"

The evasiveness of some answers to this inquiry when it concerns a boiler accident would be amusing if it were not such a serious question. The coroner usually blames the engineer, perhaps because the latter was killed, and therefore cannot defend himself. The boiler builder may hold the plant owner responsible, because of negligent usage. In turn, the owner may shift the blame to the engineer, who then claims, if he escapes the wreckage, that the owner refused to make needed repairs or buy new equipment. Perhaps the boiler inspector lapsed in vigilance, the boiler laws are inadequate, or what is most culpable, not to say criminal, that particular state has no boiler laws!

In June, 1912, an engineer was killed in a boiler accident in British Columbia. The law in that section required that studs and check-nuts be placed on slip-expansion joints. The inspector knew of the lack of this requirement, but took a chance. He surely was guilty of contributary negligence. Of what use is the law if its sworn servants fail to carry out its behests?

If heed had been given the insurance company's recommendations, a recent and much more serious explosion would in all probability have been prevented. The plant owners refused to listen, and the insuring company had no recourse other than to cancel the risk.

This instance illustrates the great need of a state court or board to which insurance inspectors could report all dangerous conditions and laxities. Then this body, after verifying the reported conditions, should have the power to force the owner either to make safe his equipment within a reasonable time or to shut down the plant until he did. Insurance companies are usually thorough and painstaking because they assume monetary risks, but the plant owners, in addition to property damage, risk human life.

All of us most willingly agree that boiler accidents are altogether too frequent; that their primary cause is criminal negligence in most instances; that "something must be done at once"—and then we promptly lapse back into the rut until the next accident arouses our indignation.

We babble over eternal vigilance in the engine and boiler room, the responsibilities of owners and managers, the frequent inspections, the safety of human life and the preservation of property, but just when are we going to adopt all these very commendable precautions?

The Victories of Peace

History as it is written and as it is taught is one great panorama of wars and dynasties. It bristles with the names of doughty warriors and rulers, describes at length their struggles and achievements, and dismisses the inventors and promoters of the great agencies which have made modern civilization possible, with scanty, if any, mention.

The invention of printing has had more influence upon the development of the race than any act of any ruler that the world has ever known; and more than half of those who read this will not know the inventor's name.

The men who invented and developed the steam engine did more to lighten human toil and to make possible to each of the dwellers upon earth a larger mead of comfort and enjoyment than all the generals who ever pitted men against their fellows. Hunt for their names in the indexes of your histories.

Art and literature have been broad highways to fame. The high-school scholar can tell you who wrote what, and when he wrote it, but ask him who built the first railroad in America, and when and where it was. The magnificent Albert Memorial is covered with the names of authors and painters and sculptors, but Michael Angelo is there because he was an artist, not because he was an architect, and Leonardo Da Vinci because he was a painter, and not because he was an engineer. Something of the spirit of contempt for the utilitarian which led Seneca to vehemently labor to clear Democritus from the imputation of having made the first arch, and

Anacharsis from the charge of having contrived the potter's wheel, is still extant. The world has still something of the feeling toward the engineer that society has for the man who is "in trade."

Have you noticed how many engineers and inventors and captains of industry have been presidents, or have even filled places of lesser importance in the conduct of the country's affairs?

The land is full of libraries which conserve the writings of those who have thought, dreamed, imagined and studied for the benefit of others, and it is well that it should be so. Every city of importance has its art museum where the visions of others expressed in different media are selected and exhibited at enormous expense, and they are good to see and to know. There are numerous museums of natural history where one may study anything from a pterodactyl to a house fly. The natural-history exhibit of the Smithsonian Institution is housed in a magnificent $3,500,000 building, but the poor little fragmentary relics of the industrial development of the country are tucked away in corners of the old one-story building, many of which are offered or could be had for the housing are necessarily refused or ignored, and industrial history is fading with the memory of those who see it made.

Peace hath her victories no less than war, and the time is ripe for a proper recognition of the men who win them, and an adequate record of the manner of their winning.

⁂

Flatbush Gas-Electric Plant

The condenser system in operation at the plant of the Flatbush Gas Co., which plant is described in this issue, deserves the serious consideration of consulting and gas works engineers particularly.

With practically no increase in installation save a few lengths of pipe, the engineers of the plant have succeeded in utilizing the water-seal troughs of a large gas holder for a storage reservoir for condenser-circulating water. The heat of this water as it comes from the condensers keeps it from freezing, thus dispensing with about one hundred boiler horsepower formerly required for such service. The decrease in coal consumption is nearly net gain because the vacuum on the turbines is increased about two inches over what was possible with the use of cooling towers alone.

This is the first time to our knowledge that such an application has been made of condenser-circulating water. The plan is applicable to any combined gas holder and electric station, and should prove advantageous in many gas-generating plants where the gas-blower engines are the only principal units. Usually these engines are quite large and are run noncondensing, while live steam is used to keep the holder water seals warm in winter.

The use of boiler-feed water for heating purposes has long been recognized as ideal where building sizes permit. The installation at Flatbush is indeed a convincing example of the success of this system.

⁂

Same Old Carbonine

On page 730 of the present issue will be found a letter from one of our subscribes describing theatrical methods of parading Carbonine before the good people of an old New England town. Readers of POWER will doubtless remember our "repudiation" and challenge of a furnace medicine of the same name, published on page 691, Nov. 15, 1912, issue. That challenge to the American Carbonine Co. to substantiate its claims has never been accepted, and in view of the information furnished by our correspondent we are led to repeat: "If Carbonine is only another of the various nostrums which have been bobbing up from time to time for the past twenty, thirty or more years for the same purpose, exploited in the same way, and failing to sustain the test of real investigation and continued use, it is right that the public should know it."

The statements of our correspondent are sufficient exposition of reasons why our challenge has never been accepted and may explain why the field of Carbonine's commercial activity appears to have been shifted from the power plant to the kitchen. Combustion of coal is a broad science and frugal housewives, who may admit that they can be taught a thing or two in this branch of domestic economy, should not be discouraged from consulting these coal doctors, even though the medicine prescribed may consist only of bread pills; but the wise power-plant owner asks only for results and will continue to demand *quid pro quo*.

⁂

Civil Service Examinations

Among the institutions of our government, federal state and municipal, the civil-service commission is a factor for much good. In many places, the commission could perhaps, be made more efficient if less political influence were used, but the commission itself deserves commendation.

We repeat this evident statement of fact because so many engineers and firemen who are not so successful in civil-service examinations as they anticipated, condemn the commission and everything allied with it. Unfortunately it is true that men are "slated" for position in reward for political assistance given, and despite the formality of a civil-service examination and the fact that they receive a lesser number of points than other competitors, they get the jobs. That is the outcome of the spoils systems, the vitality of which, we hope, will diminish in proportion to the growing manifestation of the ideal in government.

Engineers, individually or collectively through organizations, pay too little heed to the civil-service commission and the examinations given to applicants for positions in municipally- or state-owned plants. How much better it would be for engineers who belong to engineering organizations to attack collectively unfairness in appointments, instead of each emitting a growl of individual protest. And how much more fruitful of real result would it be for them to organize classes within the organization, each class headed by a live member as teacher and prepare for the examinations that are held at intervals, instead of each striving individually. Individuality will not thus be lost, but will be made more manifest.

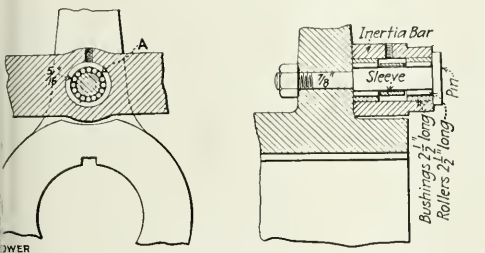
There is nothing to lose by such a plan; there is everything to gain. Even though an applicant never is fortunate enough to get a civil-service job, he has, neverthless, been bettered by study and stimulated to action that must eventually bring results. The satisfaction of having been tested, as it were, is felt to be worth while by many who do not look for appointments.

READERS WITH SOMETHING TO SAY

orrecting Trouble of Inertia Governor

We have experienced trouble from racing of our high- l medium-speed engines. The several engines in the nt are of the same make and, although of different es and style of valves, they have inertia governors, all the same make. This governor is here shown in part. e length of the inertia bar is about two-thirds the meter of the wheel; it is of the usual construction, ving one light and one heavy end, and is pivoted on a ller-bearing pin in one of the spokes. The steam ec- ntrie is clamped to the finished hub of the bar and ings across the shaft as the bar moves.

After one of the engines had been in use for about a ar the voltage became very unsteady at the usual load. metimes before switching the load to another generator was necessary to partly close the throttle to prevent e speed from becoming dangerously high when the load



Details of Ball-Bearing for Governor Pin

nt off, as the governor would "stick." The cause of trouble was located in the governor.

The inertia bar is bored and fitted with a hardened- el bushing. The length of the bearing is 7 in., but two hings, each 2½ in. long, were used, leaving a space in. wide in the center, as shown in the sectional view. ere are two sets of rollers $\frac{5}{16}$ in. in diameter and 2½ long. A sleeve 2 in. long having an outside diam- of $\frac{1}{16}$ in. less than the inside diameter of the bush- , and an inside diameter of $\frac{1}{16}$ greater than the pin, placed between the two bushings to keep the two of rollers in place. Grease is fed to the center of arm, and works toward the ends.

The first pins were case-hardened and made a very ht fit in the hub. The rollers gave a sensitive bearing n new, as there was very little friction, but the strain came on one side of the pin and bushing at about one- rter of the circumference of the pin or at the point rked *A*. After about a year's use the inertia bar taken off and the bearing examined. This was e a job as the steam and exhaust eccentrics must be n off to get to the inertia bar pin. Then the pin d the wheel so tightly that a jack had to be made ull it out, even then the threads of the 7/8-in. draw s were nearly stripped, and a sledge was used as much ossible in the limited space in order to start the pin. After it was out it was found that the rollers had worn spots into the bushing and pin. This caused the bar to stick, and caused the racing. In making new pins the engine builder who was to furnish them was consulted, and it was decided to make them and the bushings harder, and an easy tapping fit instead of a sledge-hammer fit; also, that there was to be one set of rollers the full length of the pin instead of two short sets as before. This would increase the bearing surface from 5 to 7 in. and give a harder surface. The fault with the short rollers seemed to be that they got caught in some way, and some sets seemed to be twisted in the bearing. Some of the rollers had flat spots on them, and some of the spots on the pin were not parallel to the center line of the pin. The pins and bushings in all the engines have been changed as the action of the governor made it necessary, and some of them have been in use over two years without giving any trouble from racing. I believe one trouble with the short rolls was that the bushings were not exactly in line and true.

Instead of feeding the grease in one place as was done with the old bearings it is now fed into a circular channel in the outside of the bushing, and reaches the rollers at about the middle of their length, and in three equidistant points on the circumference.

J. C. Hawkins.

Hyattsville, Md.

Cause of Knock in Pumps

Referring to John F. Hurst's statement in the Sept. 16 issue, page 404, concerning the reason why a pump will knock or give a short jerk, when it starts on its return stroke, my idea is that it is due to the pump not getting enough water to fill the cylinder before the plunger starts on its next stroke. The cause of the water supply being too small for the pump may be one of the following three:

(1) The water may be so low in the supply tank that the end of the suction pipe is exposed to the atmosphere, admitting air to the pump instead of water, or preventing a sufficient amount of water to reach the pump. When this is the case water and air are both drawn into the suction end of the pump, the air being compressible. The pressure is very much lower in the cylinder until the air is compressed to the working pressure of the pump. The plunger travels much faster at the beginning of its stroke until this air is compressed to the normal working pressure, which checks the speed of the plunger.

(2) The feed (suction) pipe valve may not be opened enough or the pipe may be partly clogged, due to the sediment in the water. If this is the case the water cannot get into the cylinder fast enough to fill the space in the cylinder before the plunger starts on its return stroke, thus causing a partial vacuum in the suction end of the pump, which would jerk the plunger back against the water as soon as the steam is released.

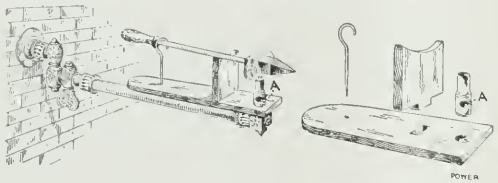
(3) The suction pipe may be too small. This would have the same effect on the plunger as the above trouble; if the springs were too weak to force the suction valves on their seat, this short jerking or kicking motion would result and continue until the spring or springs were replaced with stronger ones.

I have had trouble with pumps knocking or short jerking quite often, but I always found the causes to be the ones here mentioned.

Chicago, Ill. JOHN FERGUSON.

Heating Soldering Iron by Gas

The illustration shows an attachment for an ordinary gas fixture used to heat soldering irons. I have one of these in my engine room and it gives satisfactory service.



APPLICATION OF ATTACHMENT

Little explanation is necessary as the sketch shows clearly how the attachment is made and assembled. The burner may be one from a mantle light or an ordinary burner with a hole A cut in the side to admit air for making a blue flame.

Roxbury, Mass. CHARLES GUNN.

Soda Ash for Boiler Waters

I have read with interest the abstract from a lecture by Charles H. Bromley on "Soda Ash for Boiler Waters," appearing in the Sept. 16 issue.

As I understand it, the purpose of the article is to prove that solutions of soda ash (sodium carbonate) will prevent any boiler from corroding with any water for any length of time if its concentration is maintained at or over 3 per cent. normal strength.

To prove this contention, the lecturer cites one example and from this one example sets forth a general principle, applicable to all waters and all conditions. The statement attributed to Heyn and Bauer, that dilute solutions of sodium and potassium carbonate promote corrosion instead of stopping it, is given without reference.

Regarding the corrosion on the ship "New Jersey," using a dilute solution of soda ash as compared with no corrosion on the "Oregon," from a scientific standpoint, would it not have been advisable to have proved that a strong solution would prevent corrosion on the "New Jersey," even in the boilers had to be run with difficulty?

In the writer's opinion, an article of this kind does a great deal of harm, since there is little question of its main contention being erroneous when stated as a general fact. There are waters wherein the use of soda ash directly in the boiler, may result in corrosion of the boiler and of the steam piping, but such waters are not the eral rule and soda ash not the primary cause.

Soda ash is being used, under almost every conceiv condition, in extremely dilute solutions in thousand boilers all over the United States. The cases where ash is charged with causing corrosion are extremely and an investigation of these cases will show that the abundant cause for corrosion from other sources.*

The writer's experiences with the use of soda as waters from which all the free and half-bound carb acid (CO_2) has been removed, covers about 500 diffe boiler plants, ranging in size from 500 hp. to 37,500 with almost every type of boiler. He has yet to fi single case of corrosion in this number of boiler plan any part of the feed lines, boilers or steam piping. strength of the soda-ash solution in the boiler-feed w is rarely over one or two grains per U. S. gallon, and over 500 grains as a maximum in the water after centration in the boiler.

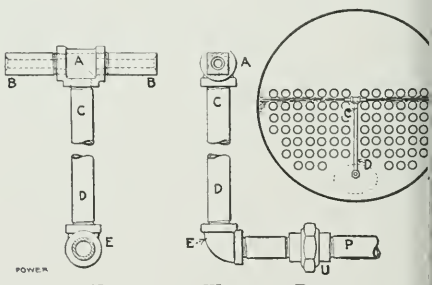
Soda ash is not a "cure-all" and is not a proper rea to be introduced into the boiler under all conditions when properly used in the purification of water doe hibit corrosion.

J. C. W. GRET

Pittsburgh, Penn.

Nozzle for Washing Boilers

Mr. Bornmann's article on washing boilers was interesting and the device that he uses is a good There is one change, however, which I think woul an improvement on the device, and that is to u swivel joint at *E* (his Fig. 1) instead of a rigid ell.



NOZZLE FOR WASHING BOILERS

ells would do, but a swivel joint that could be fix any desired position would be better. By this mea pipe *C* would not have to be changed, as the pipes *P* could be turned to a greater angle than 90 deg., would be practically the same as using a shorter This would permit its use on the lower rows of tu well as the upper rows, and, although it would not back as close to the front head, this space could be w by turning the nozzle sideways as far as the m would allow, and also by water running down fr upper rows of tubes. I should also use a rounc nozzle instead of a square one for the reason that the square one will have a scraping action on the

Previous discussion of this subject appeared in the issues of Sept. 30, p. 481, and Oct. 28, p. 613.

*[Mr. Greth's statement that "cases where soda charged with causing corrosion are extremely rare," is esting, for many of those who have used it have expe corrosion troubles which they attributed to the pres the soda ash. Discussion of this matter would be welc Editor.]

two center rows of tubes there are many boilers in ch the tubes are spaced so close together vertically sometimes they are warped so that there would be a sibility that the square nozzle when turned at an angle ld bind on the tubes while a round nozzle would not, would have the same scraping action as a square one.

J. C. Hawkins.

Hyattsville, Md.

Says Bucket Traps Are Best

n our plant there are many steam traps of various es, including those of the expansion, drip and bucket e. After going very closely into the matter, I find t the bucket type undoubtedly is superior, both as to ability, steam consumption and in getting rid of water. cost for maintenance is less than with other types. The chief trouble with the expansion trap is that the al parts seem to alter in length after being subjected working conditions for a few months. This length- ng or shrinkage of parts alters the adjustments, and ble usually follows. When these traps are not set to off quite tightly the seat is soon cut, thereby establish- a perpetual leak until the valve is reground. With the bucket-type trap, unless dirt has got under seat, there are only two positions in which it is pos- e for the valve to stop, either full open or closed. ain, with this type of trap, steam never blows through n the discharge unless the bucket is rubbing or be- es tight on its trunnion or hinge.

n one particular instance by the introduction of ket traps and the removal of expansion traps it is ex- ed that enough will be saved in nine months to pay the change.

E. R. Pearce.

Cochdale, Eng.

fety-Valve Problem for Discussion

n experience with a lever safety valve which would v wide open has interested me considerably. The valve a flat disk and was set to blow at 15 lb. It worked right until it had lifted about $\frac{3}{16}$ in., when it moved denly to a wide-open position. Later, I experimented n other valves, holding them down until the pressure increased 2 or 3 lb. above that at which they operated, n letting them go, when they would lift as high as I ld allow.

t is shown in textbooks on the mechanics of fluids notion that the force of a stream impinging on a flat face larger than the stream is twice as great as the l corresponding to the velocity of the stream. In r words, if the end of a nozzle be covered with a flat e and the pressure necessary to hold it there be de- mined and then it be moved away from the end far gh for the issuing stream to attain its highest veloc- and the pressure exerted upon it be again determined ; ill be found that the pressure has been nearly doubled would be doubled if it were not for the frictional re- ince upon the stream offered by the nozzle. Of course, plate must be large enough to arrest the motion of the re stream or the pressure will be less.

think that in the case of the safety valve, after it lifted a certain distance, the vertical velocity of the steam becomes great enough to slightly increase the pressure upon the disk. This increase would only have to be slight as the resistance of a lever valve remains constant as the disk is lifted, whereas the resistance of a spring-loaded valve increases.

But what I am most interested in is how likely is this to happen in practice. If readers have had similar experiences, I would like to hear from them through Power.

Such an accident might prove serious or, at least, alarming, especially at high pressures, for the lift of a safety valve is ordinarily $\frac{1}{8}$ in. or less and when it opens an inch or more, the rate of evaporation is enormous and the water is thrown against the top of the shell with more or less force.

H. H. Hastings.

St. Louis, Mo.

Damage by Water in Engine Cylinders

The article on the above subject which related the experiments of H. Bollinckx was read with interest. Despite the positive statement made as to the improbability of water doing damage after it gets into the engine cylinder, and the fact that the experimental engine was "stuffed" with water from a pump provided for that purpose and suffered no serious injury, one finds it difficult to even force himself to agree with the argument.

I think it possible in some cases for water to return to the cylinder from the exhaust pipe, but the danger from this source is slight, for the valves operate wrongly to make much of a pump of the engine with the exhaust pipe for the intake. Whatever water follows the piston from the exhaust pipe must leak by a closed exhaust valve, but as valves will lift considerably on some engines it is possible that enough might get into the cylinder and get caught after the exhaust valve closed on the return stroke to more than fill the clearance space, in which case damage would result. I do not doubt that an engine can be so adjusted (with exhaust remaining open to extreme end of stroke) so that water from any source will do little or no damage, but with the usual adjustment with more or less compression, a slug of water, either from the exhaust or steam pipe is sure to do damage if more than enough to fill the clearance remains in the cylinder up to the time exhaust completely closes. As water has a velocity much lower than steam at the same pressure, it is likely to get out last.

My experience with water in engine cylinders teaches me that no chances should be taken in ordinary engine-room practice despite the assuring tone of the article referred to.

L. Johnson.

Exeter, N. H.

A Dangerous Mistake

A boiler having been cleaned and repaired, was being filled preparatory to being put in service.

After waiting the usual time for the water to make its appearance in the gage-glass, the attendants became apprehensive. As the water still failed to show, the boiler commenced to overflow from the open safety valve. No water was visible in the glass. It was then remembered

that a steam fitter had had the water column down repairing it. The water was run out of the blowoff to a point below the bottom flange on the column.

The gasket was removed, and, as surmised, the center had not been cut out. The column was connected and after filling, the boiler was fired up. Upon attempting to test the column by blowing down, it was discovered that there was no circulation in the column. The glass appearing to be full all the time. That the glass was not giving a correct reading was discovered by using the try-cocks. The boiler was cooled off and again emptied when it was found that the same mistake had been made with the gasket at the top of the column.

This is a dangerous mistake as the pressure was all from the bottom of the glass, it would stand full regardless of the true water level inside the boiler.

EDWARD T. BINNS.

Philadelphia, Penn.

Carbonine

The American Carbonine Co. has established a manufacturing and distributing agency in Lynn, Mass., and with placarded automobiles and a propaganda of advertising is assisting the conservation of coal movement to the best of its ability. The concern claims that a saving of from 25 to 33 per cent. can be effected with coal treated with Carbonine when used according to directions, although this apparently exorbitant claim should easily be substantiated—if the directions are followed to the letter. The directions for household use state that "one teaspoonful of Carbonine is to be dissolved in a cup of *hot* water and sprinkled on coal in hod." Then, "Be sure and use one-third less coal and less draft." Simple, isn't it?

With the purpose of acquainting himself with facts available the writer visited the salesroom of the company where information was freely given. No steam plants were said to be using Carbonine in the vicinity, but a test was conducted at one of the large factory plants about one year ago and a saving of 25 per cent. was claimed, though, strange to say, no Carbonine has been used at this plant since making the test. Furnished with a copy of the report of the test I visited the plant where further information as to the monthly statement of coal consumed together with the corresponding readings of the feed-water meter was obtained.

Following is the report of the test as issued by the Carbonine company:

Treated Coal Nov. 1–15, 1912		Untreated Coal Dec. 1–15, 1912	
Coal, soft	81,945	Coal, soft	132,030
Screenings	81,945	Screenings	66,085
Total	163,890	Total	198,045
Hours run	60	Hours run	60
Av. hp. per hr.	476	Av. hp. per hr	467
Lb. per hp. per hr.	2.24+	Lb. per hp. per hr.	3+
Daily coal lb.	12,807	Daily coal lb.	15,234
Water lb	114,010	Water, lb.	125,780
Av. temp.	0.35	Av. temp.	0.33
Cost	$256.06	Cost	$340.73

While discussing the results shown by the report, the engineer who conducted the test admitted that 2.24 lb. of coal per horsepower-hour, representing a water consumption, based on the daily coal and water data in the treated coal report, of less than 20 lb. per horsepower-hour, is "a little lower than is generally considered possible for a 24x48, high-pressure engine performance." The dis sion finally led to the admission that the figures v simply rough estimates which, of course, nullifies comparative value of any information which the re might be expected to impart.

The items marked "daily coal" and "water" are to be "fairly accurate" weighings and reading of the f water meter for one 10-hr. run. Computing from t values it is ascertained that the evaporation with treated with Carbonine was 8.90 lb. of water per po of coal; while with untreated coal, though the mix was 2 of coal to 1 of screenings, the evaporation was lb. of water per pound of coal.

These figures appear to indicate a saving due, haps, to the Carbonine treatment. However, a comp son with the coal and water records for three mon when approximately the same mixture of coal and scr ings was used, shows evaporative values during months greater than is accredited to the Carbon treated coal.

Months	June	July	Augus
Coal, soft	118,620	107,150	121,4
Screenings	111,660	132,960	152,8
Totals	230,280	240,110	274,3
Water (cu.ft.)	32,150	35,650	39,5
Actual evaporation per lb. of coal	8.7	9.27	9

At another steam plant where Carbonine was tried engineer thinks that there was a slight saving in f of Carbonine, though if the Carbonine had to be chased, the cost would have exceeded the saving obser

At a city plant where apparatus is installed for ducting fuel tests. Carbonine was tried for one w Figures of these tests are not available, but the el engineer's statement that "so far as could be ascerta the treatment of Carbonine made no difference in results obtained" coincides with the views cited abov

Apparently, there is a market for Carbonine in "home combustion" field as it is no secret that abou per cent. of the heat value of the fuel burned is wa through careless manipulation of the draft, so if th struction "Be sure and burn one-third less coal, and draft" can be consistently complied with and the hea and cooking satisfactorily accomplished, providers sh recognize that its use may be accompanied by some l fit to household economy.

Lynn, Mass. CHARLES F. ADAM

Economy of the Steam Loop

Much has been written about the steam loop an method of returning the condensation directly to boiler. To be sure, its simplicity is in its favor, b in other power-station apparatus, economy canno overlooked.

The condensation will readily flow into the drip ceiver by gravity and the flow from the elevated rec into the boiler is due, of course, to the receiver pre plus the head, overcoming boiler pressure.

The energy required is in lifting the conden from the lower receiver to the upper and caused difference in pressure again. This is provided by ing more or less steam to be vented to the atmos Now, the point is, how does this method compa economy with that of a pump, maintained in good tion, and the maintenance noted, when the exha utilized?

Union Hill, N. J. L. W. CULP

INQUIRIES OF GENERAL INTEREST

Paralleling Exciters—Will two exciters operate satisfactorily together when one is compound wound and the other shunt wound?

M. L. W.

No. If they must be operated in parallel it would be better to cut out the series winding of the compound-wound machine and operate both machines with shunt windings only.

Tube Beading—How much should 3½-in. tubes project beyond the heads of a return-tubular boiler at each end, to allow for beading when retubing a boiler of this type? Should the tubes be annealed before using?

B. H. S.

About ¼ in. Standard boiler tubes used in standard lengths do not require annealing for rolling or beading as they are already properly annealed, but if cut to shorter lengths than furnished by the manufacturer, the cut end should be annealed.

Boiler Feeding—Why is an injector for boiler feeding considered inefficient, when, except for the small amount of heat lost in the overflow, the heat of the steam consumed is returned to the boiler in the water?

J. B.

Injectors are more economical of steam than feed pumps, but for many purposes this advantage is offset by the objections that they become clogged, can draw only cold or moderately warm water, require dry steam for their operation and some skill to handle and that they generally are not adapted to graduation of feed nor continuous feeding.

Setting Thermostat—Having no thermometer or other instrument to measure the temperature how can a thermostat be set to operate at 376 deg. C.? There is a well in the steam line for a thermometer. Could not some substance be put in this well that would burn, melt or otherwise indicate when about the temperature required is reached?

L. B. T.

Lead melts at 620 deg. F. and zinc at 786 deg. F. Adjusting the thermostat to operate between these limits would probably be close enough to the desired temperature, 376 deg. C, or 709 deg. F., for all practical purposes.

Removing Tube Scale—How may the scale be removed from old boiler tubes which have been taken out to be lengthened by welding pieces on the ends?

B. H. S.

Boiler flues in quantities are cleaned in flue-cleaning machines by hanging a number of tubes in the loops of a pair of endless chains running over sprockets on horizontal shafts. Cleaning is accomplished by causing the tubes to roll over and over each other. Ordinary boiler scale can usually be cleaned with a strong solution of soda ash, after removing the thickest scale by lightly hammering the exterior surface of the tube.

Purging the Absorber—How often and where should the absorber of an absorption ice machine be purged? Is not the valve on the side for drawing a sample to test the strength of the liquor?

R. F. P.

At regular intervals, say once every two or three months, blow off whatever air or other noncondensible gases have accumulated. Usually absorbers are blown off at the top as most of the gases contained are lighter than ammonia vapor. If there is any other valve except the purge valve, it can be used to draw off a sample of the liquor, but care should be taken that this valve is close to the strong liquor line where it leaves the absorber, otherwise the sample drawn may not represent an average of the strong liquor used in the refrigerating cycle.

Bolt Strain—Knowing the tensile strength of a bolt, how may it be calculated what force applied on the wrench handle in tightening the nut will break the bolt?

C. H. W.

Neglecting friction, the tensile strain will be equal to the force applied to the wrench, multiplied by 2 times 3.1416 times the distance (in.) of the force from the center of the bolt, divided by the pitch of the screw (in.) As in screwing up a nut the friction of both the screw thread and the bearing face of the nut must be overcome by the force applied to the wrench, the amount of tension brought on the bolt will depend on what per cent. of the power is lost in overcoming friction. In ordinary metal work the actual pressure of the nut or tension on the bolt would be 80 to 95 per cent. of the tension calculated without friction, depending on the character of the bearing surfaces.

Turbine Bucket Erosion—What is the relation of steam velocity to bucket erosion in steam turbines? It has been stated that the erosion is proportional to the square of the steam velocity, but that such a fixed law could hold hardly seems possible.

A. E. M.

The statement mentioned evidently is founded on the assumption that the work of erosion would be as the square of the steam velocity, but the rate of erosion would depend on the characteristics of the metal of the bucket as well as the velocity of steam, and it would be very difficult to state a fixed law. The rate of erosion is unquestionably influenced by the wetness of the steam and by solid particles of piping, nozzles, etc., that may be carried along with the steam, but the extent would depend on conditions for any particular case.

Simultaneous Pump Suction from Different Levels—A water supply is taken from two lakes about 1¼ miles from the plant, the farther lake 15 ft. higher than the nearer one and containing the larger amount of water. Water runs in from the far lake of its own accord, but this lake usually runs dry in August, compelling all of the water to be taken from the nearer lake and then pump trouble begins in loss of priming. Could a device be arranged to utilize the excess head of the farther lake to pull part of the water from the nearer lake, say three-quarters from the farther one and one-quarter from the nearer one, that would be automatic in its action? Such a device would save exhausting the farther lake.

C. G.

Probably a "jet pump" in the nature of a water ejector or eductor could be placed at the junction of the pipes leading from the lakes and the ejector could be so designed that the 75 per cent. supply of water drawn from the higher level could be employed for drawing in and carrying along the 25 per cent. of supply to be taken from the lower pond.

Air-Pump Power Consumption—What power would be consumed by a single-acting air pump making 60 r.p.m. geared down from a shaft running 1500 r.p.m. and working against a pressure of 120 lb., the pump having a 6-in. stroke and a 3-in. bore?

A. C. R.

The net power developed would be found by the formula

$$\text{Hp.} = \frac{P \times L \times A \times N}{33{,}000}$$

in which

P = Pressure, lb. per sq.in. (120);
L = Length of stroke, ft. ($\frac{6}{12}$);
A = Area of cylinder, in. (7.0686);

and

N = Acting strokes per minute (60).

Then,

$$\text{Hp.} = \frac{120 \times \frac{6}{12} \times 7.0686 \times 60}{33{,}000} = 0.77 \text{ net hp.}$$

The efficiency of the air pump would be about 60 per cent., so that the power required to be applied to the pump would be

$$\frac{0.77}{0.60} = 1.283 \text{ hp.}$$

The efficiency for the gearing would be about 90 per cent., so that the total power taken from the shaft would be

$$\frac{1.283}{0.90} = 1.42 \text{ hp.}$$

ENGINEERS' STUDY COURSE

Lubrication

Friction is the resistance of one surface sliding upon another; it is due to, and its extent depends greatly upon, the roughness of the surfaces. All surfaces, no matter how smooth and polished they may seem to the unaided eye, possess minute projections and hollows. Hence, when one surface is rubbed on another the projections of one catch into the hollows of the other and must be broken or worn off or lifted out before any sliding may take place. All this takes energy, and the amount of energy thus spent is called the loss due to friction.

Some surfaces naturally offer less resistance than others, and the condition of a surface also has its influence. Other things being equal the friction between two surfaces is almost directly proportional to the total pressure. The area of contact has but small influence except in extreme cases. The speed at which the surfaces rub over each other, provided this speed is not excessively low or high, has practically nothing to do with the amount of the friction developed. These things being true, the friction that a given bearing will develop can be estimated simply by figuring the weight to be carried and multiplying by a factor based on the slipperiness of the bearing surfaces. This factor is generally known as the coefficient of friction.

To reduce the effect of the naturally more or less rough nature of a bearing surface lubricants are employed. These are forced or work their way between the surfaces in contact, and tend to separate them, with the result that the minute projections and hollows cannot mesh thoroughly and, hence, the friction is reduced.

Lubricants are divided in three classes, solid, semi-solid and liquid. The action of the first two classes seems to be similar to that of a set of exceedingly minute rollers, which carry the weight or sustain the pressure while the bearing surfaces slide or roll on them. The action of the liquid lubricants is to form a film between the bearing surfaces upon which the pressure-imposing surface literally floats.

Solid and Semi-Solid Lubricants

The solid lubricants are graphite, plumbago, soapstone, etc. The first-named is the most widely used. To yield good results the bearings in which they are used should be of very hard material. Graphite is often mixed with oils and greases and usually a better lubricant results.

Semi-solid lubricants, or greases as they are commonly called, are made principally from mineral oils to which are added lime, soda or similar solid matter which will mix with the oil to form a smooth plastic substance.

Liquid Lubricants

Liquid lubricants or oils are divided into three groups, animal, vegetable and mineral. The animal oils commonly employed are lard, neatsfoot, tallow and whale or sperm oil. Those of vegetable origin are castor, corn and rape-seed oil. The oils of these two classes are known as fixed oils and solidify at ordinary temperatures. The animal oils solidify at higher temperatures than the vegetable variety. Animal and vegetable oils have the property of combining with oxygen from the air and for this reason are seldom used pure because the oxidation process causes them to become gummy and tend to increase friction. They are often mixed with mineral oils, however, as the latter are unaffected by oxygen.

The mineral oils are obtained from crude petroleum and form the class most extensively used for lubrication at the present time. Although petroleum is composed almost entirely of hydrogen and carbon, these two elements are combined in such a vast variety of proportions that by a process of refining the petroleum can be reduced to many products of widely different physical characteristics and uses. By applying heat in gradually increasing intensity and condensing the vapors given off, various products are obtained, beginning with the thinner or more volatile distillates, such as gasoline and benzine, then come the kerosenes and, finally, the various grades of lubricating oils. The latter are generally put through a process of purifying before they are sold for use. This consists chiefly of removing odor-forming constituents, any tarry substance that may have been formed during distillation, and improving the color.

After refining, the mineral oils may be compounded with animal or vegetable oils so as to yield a product possessing some of both the desirable and undesirable qualities of each. Animal and vegetable oils possess higher lubricating value—a higher degree of "slipperiness"—than the mineral variety. Hence, when compounded, they make for a more effective lubricant. But as has been stated, they also possess the troublesome quality of gumming when exposed to the air, which the mineral oils do not. Hence, compounding serves to bring this factor within practicable limits.

Testing Oils

It is the opinion of many that the best test of a lubricant is that of service. In the case of greases this is about the only test within the reach of the engineer.

In the case of oil, several simple tests can be made before the real test of service is given. But here, too, the latter is the only truly reliable test that can be made. The other tests are often worth while, however, as they assist in comparing one lot of oil with another.

The usual tests made are viscosity test, specific-gravity test, cold test, flash test, fire test, gumming test, acidity test, and test for animal and vegetable oils and for "oil-pulp."

Viscosity

Viscosity is that quality of a liquid which tends to prevent its particles from separating; in other words, it is the quality which determines whether a liquid flows freely or sluggishly. Molasses is said to be very viscid because it "runs" slowly, while the viscosity of alcohol is low because it "runs" easily. The temperature of some

liquids, among which are the oils, has great influence upon their viscosity, the higher the temperature the more easily they flow. For this reason, the viscosity test, as usually conducted under ordinary temperatures, has little or no direct significance, especially in the case of the cylinder oils which are used at temperatures of 300 deg. or more.

The viscosity test is made with a viscosimeter of which there are numerous makes on the market. Most of them show the degree of viscosity by the time required for a given quantity of liquid to run through an orifice of given size. One make, however, employs a disk which is rotated in the liquid to be tested and the viscosity is estimated from the resistance the liquid offers. Viscosimeters range in price from $1.75 upward. For simply comparing oils or different shipments of the same oil a home-made apparatus will answer well enough. In its simplest form such an apparatus would be nothing more than a funnel, preferably of glass, with a small neck. In testing, the thing to remember is to keep conditions uniform throughout all tests made.

Fix the funnel in an upright position in a firm support, first making sure that it is clean and dry. Then measure accurately a given quantity of oil such that all of it can be put into the funnel at once. Stop the neck of the funnel with a finger or plug and pour in the measured oil. If more convenient, a mark can be placed on the funnel near its rim and the oil measured by filling the funnel to this mark. When the oil has been measured and filled in, remove the finger or plug and note the exact time by a watch or clock which shows seconds. If a stop watch is available better work will be possible. If the funnel used is of glass, a second mark can be placed close to or on the neck or narrow part and when the oil has run out to this level the time should again be noted as closely as possible. The elapsed time is an index to the relative viscosity. If the funnel is not transparent some other means of gaging the point of taking the second-time reading must be employed. A suitable point would be at the instant when the stream from the funnel broke into drops.

If the reader possesses the apparatus specified in the Nov. 4 lesson he may use the burette as a viscosimeter more conveniently perhaps than a funnel. In using it, however, care must be taken that the stop cock is always wide open, that the oil is filled in to the same level for each test and that the time is always taken when the oil runs out to a given level. As temperature has an important effect on the viscosity of oils care should be exercised in having the temperature of the oil and room always uniform in both summer and winter.

Specific Gravity

The specific gravity of a substance is the ratio of its weight to the weight of an equal volume of water. Thus, when we say the specific gravity of lead is 11.4, we mean that a cubic foot of lead weighs 11.4 times as much as a cubic foot of water at standard temperature. Hence, knowing the weight of water to be 62.355 lb. per cu.ft. at the standard temperature of 62 deg. F., it is an easy matter to multiply this figure by the specific gravity of lead to find the weight of the latter, thus

$$62.355 \times 11.4 = 710.8\ lb.$$

weight of 1 cu.ft. of lead.

The specific gravity of a solid body is found by dividing the weight of the body in the air by the difference between its weight in air and its weight when submerged in water. But the specific gravity of a liquid is usually found by means of a hydrometer or glass tube with a bulb at its lower end partly filled with mercury and with a scale on its upper end or stem. The hydrometer is placed in the liquid to be measured and being heaviest at its lower end floats in an upright position. The depth to which the instrument sinks depends upon the density of the liquid or its specific gravity. For oils, the Baumé hydrometer is the instrument usually employed. This instrument gets its name from its inventor and the scale on its stem, divided into degrees, is known as the Baumé scale. Hence, the specific gravity of oils is usually stated in degrees Baumé.

To convert degrees Baumé to specific gravity, where the liquid is heavier than water, divide 145 by the difference between 145 and the gravity of the liquid in degrees Baumé, as shown by the hydrometer. Where the liquid is lighter than water, divide 140 by the sum of 130 and the gravity of the liquid in degrees Baumé, as shown by the hydrometer. For accuracy, the liquid being tested must be at 60 deg. temperature. If it is not convenient to have the oil at 60 deg., for every 10 deg. above 60, subtract 1 deg. Bé. from the reading.

Cold Test

The cold test is not necessary unless the oil is to be used where the temperature is low. To make this test pack a 4-oz. bottle containing 1 oz. of oil and a thermometer of suitable range and size in a freezing mixture. When the oil hardens, remove the bottle and as the oil begins to warm up and soften, stir constantly to keep the temperature uniform throughout the mass. When the oil will run from one end of the bottle to the other read the temperature of the thermometer.

Flash and Fire Tests

This test (flash) also has its chief value as a means of identification, but in some cases it is valuable as a precaution against using an oil where the temperature encountered might cause danger of a fire.

The simplest form of test is to heat a quantity of oil in an open porcelain dish until flashes of flame across the surface of the oil are caused when a lighted stick is brought close to, but not touching it. A thermometer of suitable range is necessary and this should be immersed in the oil so that the bulb does not touch bottom.

The fire test is conducted in the same way as the flash test, except that the heating is continued until the oil gives off vapors fast enough to burn continuously, when a flame is applied. The temperature at that point is the fire-test temperature.

The balance of the tests, being complicated and difficult, are seldom attempted except in a properly equipped laboratory by a trained expert. However, inability to make these tests should not prevent a wide-awake engineer from securing a suitable and reliable grade of oil for his plant. An oil that is not suitable or one of inferior grade that is sold at a high price is bound to show up poorly in service.

Selecting a Lubricant

The selection of the best lubricant for a certain application is no simple problem. The man who is to secure

the best results must devote much attention to controlling conditions and learn largely by actual experience.

Generally speaking, the important factors are the speed and pressure of the bearing surfaces and, sometimes, temperature. Due precaution must be taken that the nature of the bearing surfaces is suitable; that the surfaces are in good condition and that the manner of supplying the lubricant is right.

According to W. H. Bailey, quoted in "Kent's Mechanical Engineers' Pocket-Book," the general requirements of a good lubricant are: Sufficient body to keep the rubbing surfaces free from contact under maximum pressure; greatest possible fluidity consistent with the foregoing condition; lowest possible coefficient of friction; greatest capacity for storing and carrying away heat; high temperature of decomposition; power to resist oxidation or the action of the atmosphere, and freedom from corrosive action on the metals of bearings.

For bearings under heavy pressure and operating at low speed the best lubricants are heavy greases and oils or solid lubricants. With higher speeds and lighter pressures, thinner or lighter oils or greases are suitable.

Prof. A. H. Gill gives the following hints in selecting a lubricating oil for bearings: Use the most fluid oil that will stay in place and do the work. The flash point should not be less than 300 deg. F. The best oil is that which possesses the greatest adhesion to metal surfaces and the least cohesion among its own particles. For light pressures and high speeds use mineral oils having a specific gravity of about 30.5 deg. Bé. and a flash point of not less than 360 deg. F. For ordinary service use mineral oils of from 25 to 29 deg. Bé. and having a flash point of between 400 and 450 deg. F.

Cylinder oils are usually compounds of heavy mineral stock and from 1 to 10 per cent., sometimes more, of fixed oil or fat, such as tallow oil, tallow, lard or lard oil. The reason for thus compounding is because pure mineral oil cannot adhere to wet surfaces and most steam cylinders are wet. The fixed oils and fats, however, readily mix or emulsify with water and this mixture does adhere to wet surfaces. Thus, by compounding mineral and animal oils, effective lubrication is secured. Care must be exercised, however, that only the necessary percentage of fixed oil or fat is used, because this very quality of mixing with water may cause trouble in the boiler, if the exhaust is returned with the boiler feed.

The fixed oil or fat compounded with the mineral oil should be of the highest quality obtainable; otherwise the metal of the cylinder walls is in danger from the acids. A simple way in which to detect inferior material is by the disagreeable smell which is given off when the oil is heated.

Tests by numerous engineers and investigators have shown that the addition of a suitable proportion of a proper grade of graphite to both cylinder and engine oils improves the lubrication and tends to reduce the quantity of oil required. Its use is to be undertaken with caution, however, as unless properly handled and applied new difficulties may be encountered.

⁂

Illinois Establishes New Coal-Producing Record—Figures made public by the statistician of the United States Geological Survey show that the production of coal in Illinois in 1912 was 59,885,226 short tons, valued at the mines at $70,294,338. This constitutes a record for the state. Coal is mined in half of the 102 counties, the total coal-formation area of the state is 35,600 square miles.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Somebody recently said that the world is awakening to the fact that the Golden Rule is just plain common sense. Sure! But it takes a real fellow to carry out its specifications. There are many, and always will be, who wouldn't know it from the Kreutzer Sonata if it were set to music.

⁂

After 48 hours' imprisonment in a power-station boiler, a Utica-Italiano inquired on his release: "Is election day over?" And he wasn't in hiding either, gentle reader, as a repeater. Dominick Gaetano clum in to clean out the boiler, and someone clamped on the manhole cover. This man's a patriot! Most of us wouldn't care a cuss whether Fusion or Tammany got in: we'd be too keen on how to get out.

⁂

Slantha! Tim Healy, who's a coroner in New York City. In this column of Sept. 2 we said that "the only thing Tim ever runs from is his friends; offices, and enemies, he runs for, and gets them. As a coroner, he looks like a dead winner!"

But Tim ran away—away ahead of his ticket. Shure, Timmy darlint, if we were to die this day, 'twould be Hivin to have ye come an' sit on us!

⁂

"A pound of laughter is worth a ton of pills," says a contemporary. We usually meld the "150" and "40 jacks" in the smile game ourselves. How high we'd bid on a ton of pills, even at 2c. a hundred— Say, is this a long ton, f.o.b., or what?

⁂

Brother Van Keuren, Famoso, Calif., sent this clipping:

"TULARE, Oct. 10.—A. Marquehose was severely burned at noon by an explosion of gas and oil in the firebox of the steel digger, at work on the trenches for water mains in this city. Marquehose was working with the oil feed to the firebox on the steam engine when accumulated gas ignited the oil. The flame shot out directly in his face. He was burned about the neck, ears and face. His hair was all singed off in front."

⁂

A West Virginia schoolma'am has installed a small isolated plant in an anteroom of the schoolhouse. It's necessarily a heating plant because it's an electric "spanker." This engine delivers 5 s.b.p.s (5 sharps blows per second). The lady engineer says that while the run is short, it's long on efficiency. Central stations might adopt the "spanker" as a means of building up a day load.

⁂

"With artificial ice, care must be taken not to let fish come in contact with it, as the ammonia used in freezing it affects the fish."—N. Y. "Times."

Help! Don't you know, dear "Times," that a couple of sticks of ammonia laid crosswise of a fish's neck just hypnotizes it so that nothing ever after will affect it?

⁂

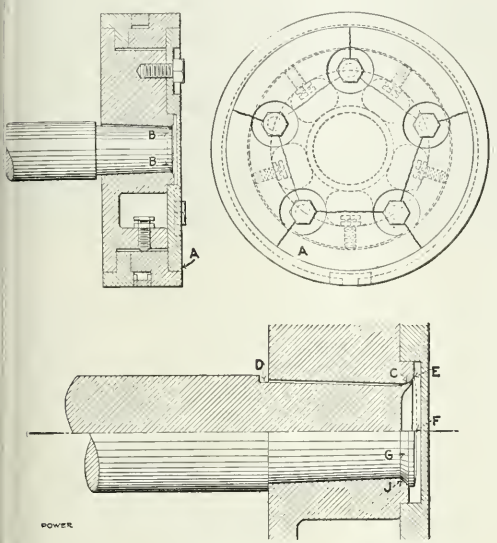
We used to think that as boosters the Western fellows took the brass ring, but that merry crowd of Beaners in the Commercial Engineers get away with the whole dinged carrousel. Now, they're boosting the coming Boston Power Show in their bright little "Bulletin." Reads like these boys just went around in bunches with their arms about each others' necks—and we bet they do, too. Get the formula, you "other" people, and be a real feller!

⁂

The Swedish scientist, Alfred Nobel, and the inventor of dynamite, left $9,000,000 as a fund, the interest to be distributed to those who had contributed most to "the good of humanity." The value of each prize foots up to about $40,000, the prizes being awarded every year. The medicine prize goes to Charles Richet, of the French Academy of Medicine, for his work in anaphylaxis. He has invented an air filter to purify the air in rooms, and act as a preventive of the spread of scarlet fever, tuberculosis and other diseases. It is a ventilator worked by electricity, which displaces 200 cu.m. of air an hour. The apparatus in which the fans revolve is covered on the inside with glycerine, on which all the germs, spores and such matter in the air are deposited and eliminated from the air of the room.

Failure of Piston-Rod Riveting

It is quite probable that failure of poor riveting of the ends of piston rods over engine pistons has been the prime cause of many mysterious engine wrecks. A case of failure of piston-rod riveting was recently brought to our attention which on analysis is easily understood to have resulted from carelessness or ignorance in design and workmanship. The quick perception of the engineer that something unusual had taken place in the right-hand cylinder of a double Corliss engine, his presence within reach of the throttle and quick action in shutting down



Failure and Repair of Piston-Rod Riveting

undoubtedly averted a smash which would probably have gone down into the history of the plant as mysterious or been attributed to negligence of the operating engineer.

The failure of piston-rod riveting occurred in the left-hand cylinder of the double 16x36-in. noncondensing Corliss engine at the Ward St. (Paterson, N. J.) mills of the Silk City Real Estate Co. The engine had been running 80 r.p.m., supplied with steam at 80 lb. boiler pressure and with usual day load cut off at about one-third stroke, the side of the engine which was crippled having carried the same load 55 hr. per week from the dates of its installation, which was about a year and a half prior to the piston-rod failure.

Ten minutes after starting for the afternoon run the engineer noticed that a slamming noise had set up against the head of the left-hand cylinder, which ceased as he closed the throttle and then as the engine was brought to rest there was heavy pounding at the end of every out stroke of the piston. Upon removing the cylinder head it was discovered that the heads of the piston follower cap-screws had been striking the cylinder head and that the piston follower *A* was broken in six pieces, as shown in the end view of the piston.

Upon removal of the follower plate it was seen that the flange riveted over the end of the piston rod had been drawn into a cupped form, as indicated by the dotted line *BB*, and upon removing the piston and rod from the cylinder it was discovered that the only remaining hold of the piston rod on the piston was by contact of the drawn-over flange and rounded countersinking of the piston, as shown at *C*.

From the amount of withdrawal of the rod out of the piston, as shown by the distance the shoulder *D* had left the piston, and the form of cupped end of piston rod, it was found that the riveting over must have been in the form *CEF*, leaving a triangular flange of little more than $\frac{1}{8}$x$\frac{1}{8}$ in. to resist stresses of shearing and drawing which for a 16-in. diameter piston and 80-lb. square-inch pressure of steam, without allowance for friction of the piston rod in the tapering bore of the piston, would amount to about 16,000 lb. The engineer is positive that the break and failure of the riveting was not caused by the presence of water in the cylinder as the water level of the boilers was low, water had never been known to be carried over, and there was no pounding or other indication of water in the other cylinder of the engine.

Repairs were made by extending the taper about $\frac{3}{16}$ in. further back on the rod and turning about the same amount off the hub of the piston at *E* and countersinking the hub about $\frac{3}{16}$x$\frac{3}{16}$ in., as shown at *J*. After trimming off the end of the rod the piston was forced on the rod up to the new shoulder, requiring a pressure of 25½ tons and then a head of the form shown at *G* was riveted on, affording about twice the previous shearing strength, and being double the thickness, should afford at least four times the resistance which the original riveting offered against being drawn over. After supplying a new follower plate and replacing the piston and rod the engine worked satisfactorily.

Ogden (Utah) Power Plant Wrecked

On Oct. 26 an opened valve on the penstock supplying water under 450-ft. head to turbines being installed in the 12,000-hp. station of the Utah Light & Ry. Co., Ogden, Utah, wrecked the plant, depriving that town of lighting and stopping the street-railway service for a short time. The loaded machinery was burned out, the plant flooded and part of the brick curtain walls carried away.

The 42-in. valve on the main intake pipe had a broken bronze ring which blocked the valve and only closed it one-half. The motor operating the valve was cut off. The steel work and the foundations of the station are not damaged. The extent of the loss has not as yet been determined.

Conservation Congress at Washington

The fifth National Conservation Congress will be held at Washington, D. C., Nov. 18, 19 and 20. It is intimated that in the next few months the fight for the protection of the country's forests and waterways will command the attention of the nation and that the question of state rights is to play an important part in the coming combat. The officials of the Conservation Congress are concerned over activities in the West in the interest of state ownership and control of the national forests and waterways. So great is the clamor in some circles that it is understood that the conservation interests realize the importance of definite steps to prevent the states from wresting the control of these resources from the Federal Government.

Gasoline Freight Engine—The Minneapolis Northern R.R. has a new gasoline freight and switching engine. It has a capacity of pulling 20 cars. Also a 200-hp. six-cylinder, air-starting and reversible gasoline engine, modified to adapt it to heavy freight service. The engine is water-cooled by two radiators, located on the cab roof, and a gear pump. One operator handles the engine and does it with ease.—"The Gas Engine."

Manhattan and Bronx, N. A. S. E., Annual Reception

At Terrace Garden, New York City, on the evening of Nov. 1, the twelfth annual entertainment and reception of the Combined Associations of Manhattan and the Bronx, N. A. S. E., was held. The attendance was very large and the whole affair most successful.

MEMBERS AND GUESTS AT THE COMBINED ASSOCIATIONS RECEPTION

Among the visiting national officers were President James R. Coe, Secretary Fred W. Raven, Treasurer Samuel B. Forse, Conductor John L. Reddy, Past Presidents Joseph F. Carney and William J. Reynolds, Trustees William W. McLean and George W. Brownhill and James D. Taylor, secretary of the life and accident department. The general committee were Lorenzo S. Everson, James D. Taylor, William M. Logan and Frederick Feldermon.

An entertaining vaudeville was given by Morgan and Morgan, comedy acrobats; Murray, Russell and Dunn, rapid-fire entertainers; Allen and Dalton, musical comedians; Braddock and Braddock, in a comedy sketch; George Andrews, comedian; Francesca Redding and Co., in a popular vaudeville offering; Clark and Watson, eccentric jugglers.

The combined associations of Manhattan and the Bronx are Brotherhood No. 1, Protective No. 23, Manhattan No. 25, Empire No. 32, Mott Haven No. 47, James Watt No. 7, Phoenix No. 24, German-American No. 29, Stevenson No. 44, Insurance No. 56.

Opposition to Buffalo Power Company

On Oct. 26 the Buffalo aldermen authorized Corporation Counsel Hammond to oppose the application of the Canadian-American Power Corporation to issue $2,999,500 of its stock to pay for a contract for the delivery of power at $12.50 a horsepower. The matter is now before the public-service commission.

Mr. Hammond says that the company proposes to build a transmission line from Niagara Falls to Buffalo city line. It appears that the proposed corporation does not now intend to distribute electrical energy in Buffalo, but, notwithstanding its plans should be carefully scrutinized, Mr. Hammond says that there is no justification for the capitalization of the contract at nearly $3,000,000, as the public-service commission in the case of the Cataract, Power & Conduit Co. refused to capitalize a contract of the latter corporation.

"The applicant company," says Mr. Hammond, "proposes to issue $2,999,500 of its common stock in payment for the contract which requires the Electrical Development Co., of Ontario, and the Toronto Power Co. to deliver at the international boundary 46,000 hp. of electrical energy for 30 years at $12.50 a horsepower. In other words, the company asks the public-service commission to approve of the issue of nearly $3,000,000 worth of stock to pay for a contract for the delivery of power at $12.50 a horsepower—a price which is higher than that now being charged for similar power in the same locality.

"If the commission should approve of this stock issue, it is apparent that when a question of rates to be charged for power comes before the commission for determination it will be difficult for the commission to refuse to consider that contract as having a value equivalent to the par value of the stock issued for it.

"The city would be in a much worse situation if it attempted to compel a reduction of rates as it was in the case of the Cataract Power & Conduit Co. In that case, a contract of a similar nature had been capitalized for a large sum of money, and although it was less than the amount of capitalization now sought, the capitalization had never been approved by the public-service commission, and the commission was in a position, as it did, without embarrassment to itself to disregard the capitalization.

"While I think no one would dispute the assertion that the bringing of additional power to Buffalo would be desirable, I think it is equally plain that the public interest requires that a company which may ultimately bring power to the city should not be allowed to issue the amount of securities largely in excess of the value of its tangible properties."

SOCIETY NOTES

The fall meeting of the New Haven Section of the American Society of Mechanical Engineers will be held on Friday, Nov. 21, at the Mason Laboratory, Sheffield Scientific School. The interesting program of papers includes "Experiments with Residence Heating Boilers at the Mason Laboratory," by D. D. Prentice, of Sheffield Scientific School. The school's electrical laboratory has been completed and an opportunity will be given during the intermission to inspect the building and its equipment.

The New York Engineers' Protective Society, the oldest engineers' association in New York City, held its 45th annual entertainment and reception on Monday evening, Nov. 1, at the Lexington Opera Assembly Rooms, which were tastefully decorated for the event. A pleasing vaudeville entertainment preceded a long dancing program. The committee of arrangements were: Andrew Olsen, chairman; William Boeringer, secretary; Charles Knudsen, treasurer.

The Ladies' Auxiliary, connected with the N. A. S. E., Brooklyn, N. Y., held its annual euchre and beefsteak supper on Nov. 4 at the rooms of the Modern Science Club. At 3 p.m. the games were started, for which prizes were awarded. In the evening a generous supply of eatables was furnished and between the courses the election returns were read by P. O. P. Smith. There was a good entertainment, which concluded with dancing.

PERSONALS

Timothy Healy, international president of the Eccentric Firemen, was elected a coroner for Greater New York on the Fusion ticket. Mr. Healy ran ahead by some thousands of votes over four other elected coroners.

John Beattie, formerly at the Long Island plant of the Pennsylvania R.R., has been appointed chief engineer of the Gould St. power station of the Consolidated Gas, Electric Light & Power Co., Baltimore, Md.

BOOKS RECEIVED

HYDRAULIC TURBINES. By R. L. Daugherty. McGraw-Hill Book Co., New York. Cloth; 156 pages, 6x9¼ in.; 96 illustrations. Price, $2.

ELECTRIC AND MAGNETIC CALCULATIONS. By A. A. Atkinson. D. Van Nostrand Co., New York. Fourth edition; cloth; 310 pages, 4¾x7¼ in.; 45 illustrations; tables. Price, $1.50.

WORKING DRAWINGS OF MACHINERY. By W. H. James and M. C. Mackenzie. John Wiley & Sons, Inc., New York. Cloth; 142 pages, 5¾x9 in.; 175 illustrations; plates; appendix illustrated and tabulated. Price, $2.

HEAT ENGINES. By William Ripper. Longmans, Green & Co., New York. Cloth; 352 pages, 4¾x7½ in.; 214 illustrations; appendix. Price, $1.10.

WORKING OF STEAM BOILERS. By Edw. G. Hiller. Taylor, Garnett, Evans & Co., Manchester, England. Fifth edition; paper and cloth binding; 147 pages, 5¼x8½ in.; 85 illustrations. Price, 1/6. Bound full cloth, 2/-.

HEAT. By J. A. Randall. John Wiley & Sons, New York. Cloth; 331 pages, 5x7½ in.; 80 illustratrons; tables. Price, $1.50.

PRINCIPLES OF INDUSTRIAL ORGANIZATION. By Dexter S. Kimball. McGraw-Hill Book Co., New York. Cloth; 272 pages, 6x9½ in.; illustrated; tables. Price, $2.50.

TURBINES APPLIED TO MARINE PROPULSION. By Stanley J. Reed. D. Van Nostrand Co., New York. Cloth; 174 pages, 7½x11 in.; 113 illustrations; plates. Price, $5.

NEW PUBLICATIONS

FOREIGN WEIGHTS, MEASURES AND MONEYS. By John J. Macfarlane. Published by the Foreign Trade Bureau of the Philadelphia Commercial Museum. Philadelphia, Penn. Paper, 6x9 in.; 62 pages, tables.

One of the first difficulties which confronts the United States merchant or manufacturer entering into trade with foreign countries is the diversity of the weights and measures used by them. The present pamphlet was written for the information of the manufacturer as an aid in establishing closer commercial relations with foreign countries. It describes the metric system and contains a very complete set of comparative tables, including a list of the various money denominations, weights and measures used in all foreign countries with the United States equivalents and also prices in foreign moneys per foreign weights or measures in comparison with our own prices per pound, yard, gallon or bushel. The comparisons in prices are made from foreign to United States and vice versa, and in the final chapter the usual foreign currency signs and abbreviations are given. To those with foreign interests the pamphlet should prove of the greatest value.

STEAM BOILERS. By E. M. Shealy, Assistant Professor of Steam Engineering, University of Wisconsin. Published by McGraw-Hill Book Co., New York. Cloth; 356 pages; 6x9 in.; 185 illustrations. Price, $2.50.

This work was written primarily for correspondence students, and is intended for the use of firemen and others who may be in charge of boiler rooms. The title, "Steam Boilers and Their Practical Operation," would have been better suggestive of the subject matter, as the operation of boilers rather than their design is treated in considerable detail. Descriptive matter relating to boilers and boiler-room equipment is included for information of firemen and others who may be familiar with only the particular equipment which they may be using. A single chapter of 19 pages is devoted to types of flue and fire-tube boilers, and another of the same length illustrates and describes ten of the more important forms of water-tube boilers, the descriptive matter being only general without referring very extensively to details of mechanical construction. The chapter on water-tube boilers closes with a section which briefly though concisely states the advantages and disadvantages of the flue, the fire-tube and the water-tube types of boilers. Chapter III on boiler calculation treats of horsepower referred to measurements of boilers; methods of measuring corrugated flues; strength of shells and of furnace flues; method of measuring heating surfaces; and general description of rivets and riveting, stays and staying.

The chapters on heat and work and on properties of steam comprise definitions of terms expressed in good language and clearly illustrated for easy comprehension of the practical mind. A chapter devoted to "Actual and Equivalent Evaporation" describes methods of determining the percentage of moisture in steam, separating and throttling calorimeters, their construction and use. The subjects of fuels, chemistry of combustion and flue-gas analysis have received good practical treatment, and the chapter on firing and the operation of leading types of stokers and chain grates and that on smokeless combustion of coal present those subjects in a manner to be appreciated by firemen, engineers, proprietors or others interested in the problem of smoke prevention.

A chapter on boiler settings contains simple explanations of Dutch ovens and details of return-tubular and water-tube boiler settings, known only by hearsay to many firemen and operating engineers whose experience has been limited to their own plants. The leading essentials of piping and boiler fittings, including a table of dimensions, weight and pitch of screw threads of pipe and fittings are given in a separate chapter, while another is devoted to clear description and explanation of boiler accessories such as dry pipes, leading types of superheaters, damper regulators, feed pumps, injectors, etc. Chapter XVI is devoted to chimneys, draft and economizers and three succeeding chapters are devoted to boiler-feed waters, feed-water heaters and the inspection and care of boilers.

The last chapter describes how to conduct evaporative tests and by an example shows the method of calculating the results, with sample log sheets for data of coal, water, draft, quality of steam and flue gas. The work is printed on good paper with text printed in large, readable type with subjects in side headings printed in heavy-faced type. The general illustrations consist of well prepared halftones and the details illustrated are reproduced to a good, readable scale.

MECHANICAL AND REFRIGERATING ENGINEERS' HANDY-BOOK. By Otto Luhr. Published by Wahl-Henius Institute, Chicago, 1913. Cloth, 6¼x9¼ in.; 900 pages; 312 illustrations; 109 tables; indexed. Price, $5.

In its 900 pages the book contains a wealth of information on practically every subject in which a refrigerating or mechanical engineer would be professionally interested. Naturally some of the subjects are treated briefly, but the material is right to the point and thoroughly uptodate. The book is admirably adapted for the practical man, and although it contains numerous formulas, these are made as simple as possible, and their application is thoroughly explained by the use of practical examples, worked out step by step, which follow in each case. The part of the book dealing with refrigeration contains over 200 pages, and as a whole is the best treatment on this subject that we have seen in print. The fact that some of the most recent apparatus brought out in this field are described in its pages, and that it contains one of the latest tables giving the properties of ammonia will indicate that it is right up to the minute. The refrigerating engineer in practice must in most cases know something about steam and electrical machinery, the transmission of power, gas engines, air compressors, and perhaps heating and ventilation. He will find it all in this book and presented in a form that he will understand.

The first chapters of the book devote 69 pages to physics, 26 pages to electricity and magnetism, 41 pages to chemistry and 38 pages to combustion. Steam boilers and accessories and calculations relating to them are given 74 pages and 59 more take up the properties of steam, steam appliances and the treatment of boiler water. Steam engines are covered in 49 pages. Sixteen pages are given to the steam-engine indicator, 14 to the steam turbine, 18 to the internal-combustion engine, 36 to the transmission of power, 22 to pumps and 9 to air compressors.

As previously mentioned the section on refrigeration is particularly good and somewhat more elaborate. Physical laws bearing on refrigeration, refrigerating systems, machines and apparatus belonging to the compression and absorption systems, the brine system, insulation, liquid-air machines and applications of refrigeration are all covered in a satisfactory manner.

Following is a chapter of 42 pages on electrical engineering, discussing briefly the principles, testing and operation of generators and motors and giving some space to converters, transformers, incandescent and arc lighting, storage batteries, and electrical calculations. Sixteen pages are allotted to heating and ventilation. Only a few paragraphs relate to hot-water heating and these to the gravity system. Short chapters on pipes and pipe fittings, friction and lubricants, mensuration, weights and measures and mathematical tables complete the book.

As will be seen some of the chapters are brief and for a more extended treatment it will be necessary to refer to some other book dealing only with the subject in hand. As a practical reference, however, giving methods of calculation and a concise summary, the book is good and can be heartily recommended to the practical man, especially the refrigerating engineer.

TURBINES APPLIED TO MARINE PROPULSION. Sy Stanley J. Reed. Published by D. Van Nostrand Co., New York, 1913. Cloth, 7¾x10¾ in.; 174 pages, 113 illustrations. Price, $5, net.

A thoroughly good book admirably covering the subject should be the general verdict of readers. The contents consist largely of a special course of lectures given by the author at the Naval Architecture Department of Glasgow University. The book is noteworthy for its fine illustrations, both halftone and line. Contrary to a practice often prevalent in books, the value of the illustrations is not diminished by overreduction. Many of the halftones are full page, and the line drawings of the turbines are on three- and four-fold inserts. Thermodynamics and mathematics are, of course, necessary in a work of this character, but are entered into sparingly as the book is primarily intended for practical use. The first eight chapters, occupying 100 pages of the book, take up the general properties of steam, turbine types, the general design and construction of the leading turbines, their steam consumption, thrust and how balanced, and nozzles. Superheated steam and types of superheater are then discussed briefly and the following chapter takes up cavitation, propeller speed and mechanical, hydraulic and electrical reduction gearing. Other subjects treated are effects of high vacua, condensers and air pumps and the utilization of engine exhaust in turbines and feed heaters. Detail of design has been eliminated except in the last chapter, which takes up a few special points on cylinders, rotors, bearings, thrust blocks, diaphragms, glands, steam pipes and turbine drains. Balancing rotors, measuring steam consumption, jointing cylinders, etc., are also given brief space in the chapter.

Able assistance by such authorities as Herr Zoelly, Professor Rateau and the A. E. G. Co. to an author thoroughly posted on his subject and knowing how to diffuse his knowledge has resulted in a well balanced book, which should prove a valuable addition to the literature on the subject.

Coal in Ancient Lake Beds

The presence of coal in the Tertiary Lake beds of certain valleys in western Montana has been known locally for many years. Some localities have even experienced brief coal "booms," most of which, however, died before the coal was developed. Systematic mining of the coal is now being carried on near Missoula.

Coal of the type found in this region has until recently been thought worthless, because only coal that would coke or stand shipment without slacking was considered of commercial value. In this part of the West, where high-grade coal is scarce, where the cost of wood has reached $6 or more a cord, and soft coal, imported for domestic use, about $8 a ton, the demand for cheaper fuel is great and the development of these heretofore unused low-grade coals is becoming profitable.

That these low-grade coals may furnish gas of good quality at a moderate cost and briquettes suitable for domestic fuel is suggested by the results of experiments with coal of a similar type recently carried on at the University of North Dakota by E. J. Babcock. On this account an investigation of the coal resources of parts of Missoula, Ravalli, Granite, Powell, Deer Lodge and Silver Bow counties, in western Montana, has been made by the United States Geological Survey in order to obtain data for the classification of the public land in the area and to supply the public with information about the coal.

The field work in this area was carried on by J. T. Pardee, of the Survey, and the results of his investigations have just been published as Advance Chapter G from Bulletin 531, entitled, "Coal in the Tertiary Lake Beds of Southwestern Montana."

Though a local demand for cheap domestic fuel will cause some further development of these Montana coals, anything like a rapid future development of them will depend on an increased use of producer gas for the generation of power, for which these coals seem well suited, or the introduction of briquetting machinery which will convert the easily slacked coal into briquettes that may be shipped and stored without deterioration.

Oil and Gas in Utah

A brief report on the oil and gas development near Green River, in Grand County, Utah, has just been issued by the United States Geological Survey as a result of a geologic investigation made last year by Charles T. Lupton, M. W. Ball and R. V. A. Mills, of the survey.

An area of about 300 square miles was examined, the object being to determine if this area, in which considerable drilling for oil and gas has been done, contains any reservoirs of these materials. In the area examined in detail the geologists found no anticlines or domes in which large quantities of oil or gas might be expected to collect. Traces of oil and small pockets of gas have been encountered in some of the wells, but in quantities so small as to afford only slight encouragement.

While the survey's report presents no very favorable impression of the field as an oil or gas producer, such deposits are recognized as among the most difficult to locate or determine exactly, and for this reason several suggestions are offered as to the portions of the field which hold out the greatest promise for prospecting. A copy of this report, which is advance chapter D of Bulletin 541, may be obtained free of cost upon application to the Director of the United States Geological Survey, Washington, D. C.

Operating Engineers, industrial concerns, and persons interested in the distribution and character of the different coals will find valuable information in Bulletin 22, just issued by the Bureau of Mines, entitled, "Analyses of Coals in the United States, with Descriptions of Mine and Field Samples Collected between July 1, 1904, and June 30, 1910." It contains the analyses of 5000 samples taken from 1500 mines and prospects situated in the various coalfields of the United States. The purpose of the compilation is to present reliable information regarding the chemical composition and the heat value. The samples were collected by experienced men and were analyzed under carefully controlled conditions. The report is in two parts, one giving the methods used in collecting and analyzing the samples, and the results of the analyses, and the other, the exact location from which each sample was taken, together with a description of the characteristic features of the coal bed at the point of sampling, the nominal capacity of the mine, and useful notes on coal preparation. The data is not equaled in scope, detail and value for comparative purposes by the figures of any other coal-producing country in the world. Some governments have published analyses of coals from different mines and from different districts, but, with few exceptions the samples were not collected and analyzed under a uniform system that would make the results comparable in all respects. Copies of this bulletin may be obtained by addressing the Director of the Bureau of Mines, Washington, D. C.

The Largest Conveyor Belts in the world, it is claimed, are being built by the Perdriau Rubber Co., Ltd., of Sydney N. S. W., for a coal-loading plant at Fort Kembla. The belts are being made after specifications of the Public Works Department; each is approximately 1650 ft. long and will weigh 12 tons, being made up of seven-ply rubber and cotton in one continuous length, without joints, 36 in. wide. When rolled each belt will be too large to pass through the railway tunnels on the way to the port. The conveyor will carry coal about 1600 ft. at a rate of 1000 tons an hour.

One of the features of the most particular interest connected with the Lemp Brewing Co.'s plant, described in our issue of Sept. 23, was the boiler-feed pump equipment. By an oversight it was neglected in that article to say that the modern equipment was supplied by the Alberger Pump & Condenser Co.

POWER

Vol. 38 NEW YORK, NOVEMBER 25, 1913 No. 22

THE DOLLAR HE IS MAKING BLINDS HIM TO THE DOLLARS HE IS LOSING

Cleveland Municipal Electric Plants

By A. D. Williams

SYNOPSIS—The city of Cleveland now owns and operates two small municipal plants but is building one of 22,500 kw. capacity. Progress on this was retarded, however, because of legal entanglements over the bond issue. The city has adopted a rate schedule giving a maximum of 3c. and a minimum of 1c. per kw.-hr.

There is now under construction in Cleveland, Ohio, a 22,500-kw. municipal lighting plant, which, when completed will be the largest municipal plant in this country. In addition there are now two small lighting plants operated by the city which came under its control when the towns that built them were annexed to Cleveland in 1910. The older of these plants is located in Collinwood. It was built in 1901 and operated in connection with the water department of that town. The second plant, known as the Brooklyn plant, is more modern, having been built in 1906 to replace an older plant built about the same time as the Collinwood plant.

Another municipal activity in Cleveland was the three-cent traction company organized by former mayor Tom L. Johnson which built and operated a number of lines and which, after considerable quarreling, was merged with the Cleveland Railway Co., by the Taylor grant, which extended the franchise of the railway company and gave a universal rate of fare of 3c. with a charge of 1c. for a transfer which, at present, is refunded by the conductor who takes up the transfer.

About three years ago a vigorous campaign was initiated to have a municipal lighting plant large enough to supply a part of the business district and to enable the city to do its own street lighting. One of the arguments in favor of the new plant was the price the city was paying for street lights as compared with those charged in other cities. The Cleveland Electric Illuminating Co. was charged with working in opposition to the proposed bond issue, one of the local papers was rabidly in favor of the bond issue, two were opposed to it and a fourth was unprejudiced. The illuminating company reduced its prices for street lights and this was hailed in some quarters as one of the favorable results of being ready to fight them on their own ground. The campaign was rather bitter on both sides and after election it was found that the proposal to bond the city for $2,000,000 to be used for the construction of a municipal lighting plant had been carried.

As soon as the new city administration under Mayor Newton D. Baker came into office steps were taken to start work on the new plant. F. W. Ballard was appointed construction engineer and A. B. DuPont consulting engineer, and an issue of $500,000 in bonds was authorized for starting construction. At this point a taxpayer's suit was started, praying for an injunction restraining the issue of the bonds and attacking the legality of the bond issue upon technical grounds, alleging that all the requirements of the state laws had not been fulfilled. The city sinking-fund commission was persuaded to invest its funds in this issue with the expectation of reselling the bonds when the legal entanglements had been cleared away.

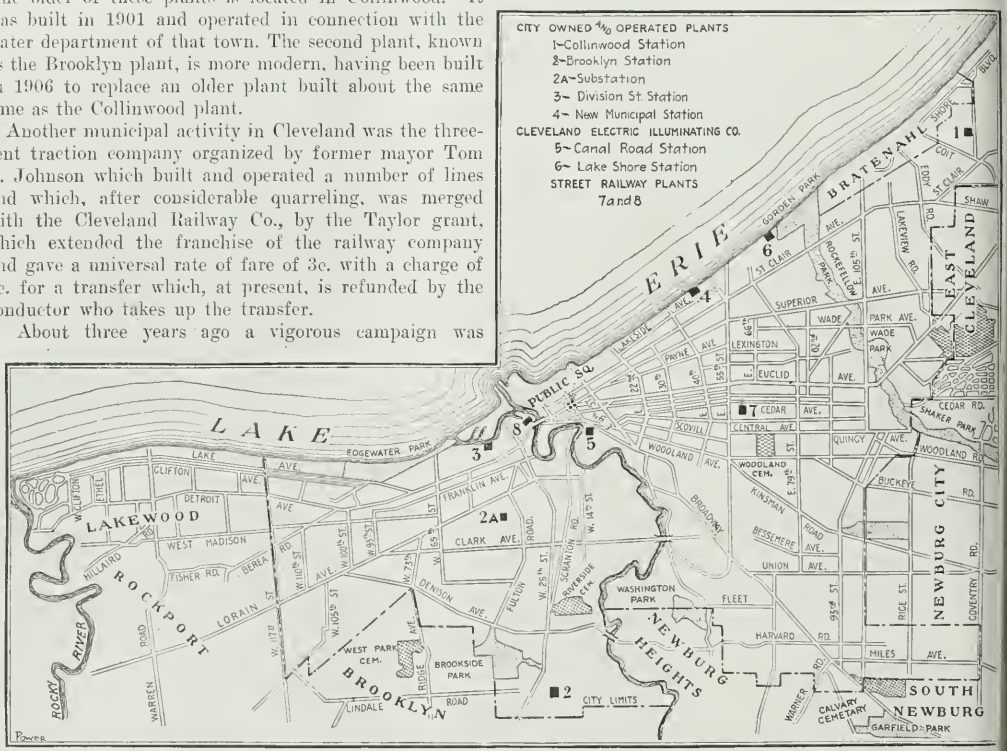


Fig. 1. Map of Cleveland, Showing Location of Electric Generating Plants

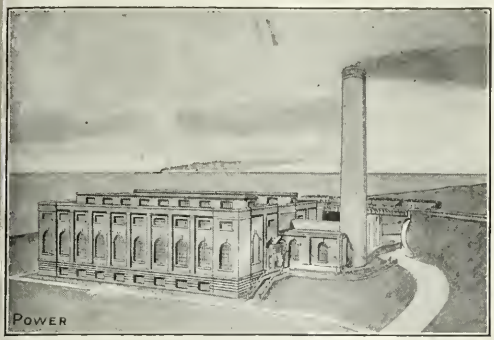


FIG. 2. NEW MUNICIPAL PLANT, FROM ARCHITECT'S DRAWING

at a certain minimum consumption, and all consumption above that minimum being charged at a lower rate. Residence and store connections have a maximum rate of 10c. per kw.-hr. and a minimum rate of 5c. per kw.-hr., the average price being about 6c. Power connections are rated in a similar manner, the prices for successive quantities decreasing to a minimum in the neighborhood of 2c. per kw.-hr. These rates are lower and more favorable both to residence and large quantity consumers than those charged in most large cities. The municipal plants have been selling current at rates slightly lower than the illuminating company and one of the issues which assisted in carrying the bond issue for the new plant was that of a maximum rate of 3c. per unit and a lower rate with a sliding scale for large consumers. In March, 1913, at a time when the lighting department expected to have the new plant in operation in the fall, a rate chart was published, Fig. 9, according to which the rate per unit varied from 3c. to 1c. and at this time several contracts were made with manufacturing concerns for a term of five years on this basis. These rates went into effect immediately for those customers taking an average service of at least 50 kw.

To illustrate the use of the chart, assume the customer has a 200-kw. service connection and he uses 20,000 kw.-hr. in any one month, his rate will be based upon

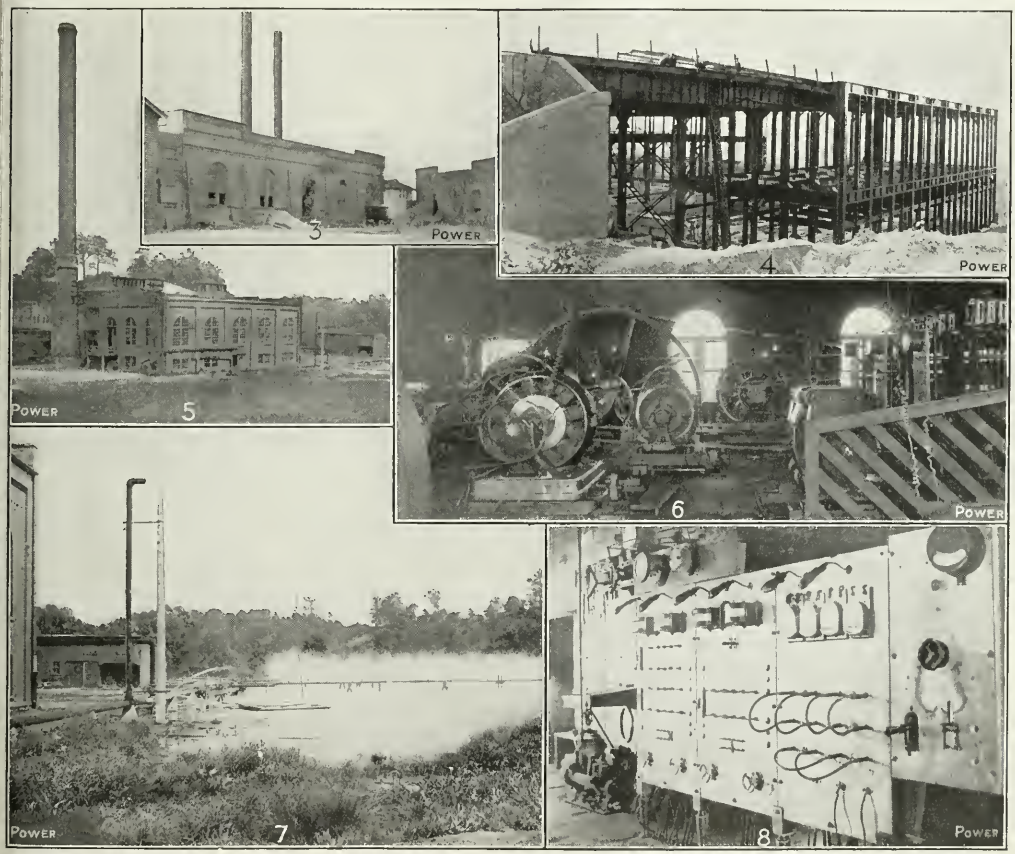


FIG. 3. COLLINWOOD PLANT. FIG. 4. STEELWORK OF NEW PLANT. FIG. 5. BROOKLYN PLANT. FIG. 6. GENERATORS IN COLLINWOOD PLANT. FIG. 7. SPRAY POND AT BROOKLYN PLANT. FIG. 8. SWITCHBOARD IN COLLINWOOD PLANT.

an average use of his full connected capacity for 100 hr. and his rate will therefore be for that month 1.6c. If, however, he uses 50,000 kw.-hr. in one month his rate will be based upon an average use of his full connected capacity for 250 hr. and his rate will accordingly be 1c. This is found on the chart by taking the intersection of the horizontal line from the 200-kw. service connection with the vertical line representing the average hours used and from this intersection following the diagonal line upward to the right-hand side of the chart. Where this diagonal crosses the edge of the chart will be found the figures which represent the rate to be paid. If the number representing the average hours used is found at the bottom of

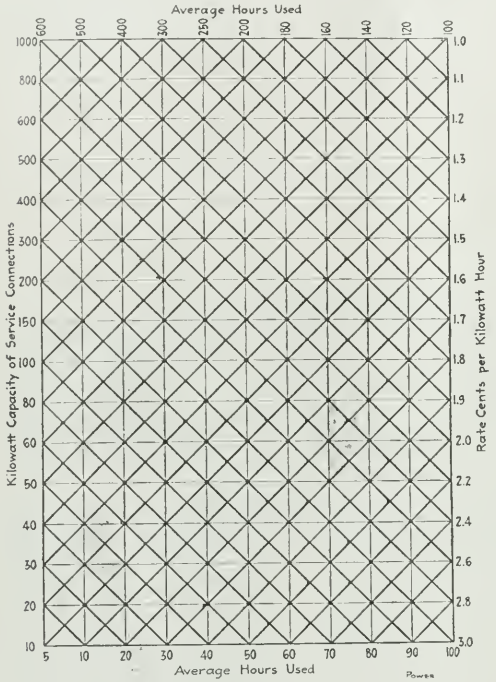


Fig. 9. Rate Chart

the chart, then the diagonal must be followed downward instead of upward to find the rate.

The chart as shown represents the rate schedule for a five-year contract. For a one-year contract use the chart in the same way, except that 10 per cent. must be added to the rates.

A minimum guarantee will be required in all contracts of 75c. per month for each kilowatt capacity of the service connection, but this is not to be added to the bill, it is only a guarantee that the monthly consumption shall equal this amount, and no bill for light or power will be less than 75c. per month.

One of the problems before the lighting department has been the limited capacity of the Collinwood plant and that at Brooklyn, both of these plants serving outlying districts. The Collinwood plant is loaded to its full capacity and the machinery is antiquated and not in first-class condition. The capacity of this plant is about 550 kw. The Brooklyn plant contains one 500- and one 1000-kw. Westinghouse-Parson turbines and serves a growing neighborhood so that an increase in capacity would soon become necessary.

A short time after the partial bond issue became available it was decided to install a 1500-kw. turbine unit in the Division St. pumping station of the Water Department, where there was surplus boiler capacity sufficient to operate it. This makes the present total municipal plant generating capacity 3550 kw.; the new plant, now under construction will add 22,500 kw.

As to when the new plant will be finished and in operation, is questionable. A second bond issue of $500,000 was authorized a few months ago by the council, but, owing to the unsettled question as to the legality of the entire issue, the bond dealers refused to bid for it and through an employee of one of the local bond dealers a taxpayer's suit was again started and the sale of the issue enjoined temporarily. The Ohio Court of Appeals has just rendered a decision, however, upholding the validity of the bond issue and placed the cost of the suit on the plaintiff. The steel frame for the new plant is practically completed and ready for the construction of the walls and roof, as may be seen by reference to the view given in Fig. 4.

One of the very interesting questions to be settled when the new plant begins operation will be the practicability of the rates at which it has been decided to sell energy. These rates, as given in the chart, Fig. 9, now apply to consumers with an average demand of 50 kw., but will be extended to cover all other connections upon the completion of the new plant. These rates will be considerably below those offered by the illuminating company which has an extremely modern and economical generating plant with a capacity of about 90,000 kw., which was described in Power, Mar. 18, 1913.

Pump-Valve Leakage

It has long been maintained that a steam pump is the most abused and neglected piece of equipment about a steam plant. But ninety-nine engineers in every hundred are perfectly satisfied that their pumps are all right, and so long as the pump runs and performs the required service they are content with things as they exist.

This condition may prevail in small plants, perhaps to a greater extent than in the large installations, but if a pump is allowed to operate month after month, and year after year, without overhauling, it is pretty evident that it is not in as good condition as it might be.

Pump ailments have been set down as short stroking, leaky piston-rod packing, leaky steam valves and piston, air leaks in the suction pipe and other minor troubles.

The accepted standard of piston speed for a boiler-feed pump is not more than 100 ft. per min., however, a lesser piston speed is advisable. If the piston packing leaks so that the water surges from one end of the cylinder to the other, the piston speed of the pump must be increased to get the desired volume of water. If the piston packing is tight and no leakage occurs past the piston, but the water valves and valve seats are worn (and all valve seats do wear), there will be excessive leakage of water past the valves, which reduces the capacity of

the pump over what it should be when running at the same speed and in good condition.

For instance, if a pump has a 6-in. water cylinder and a 10-in. stroke it will pump a maximum of 257 gal. of water per min., at a speed of 54 r.p.m. Suppose that the suction- and discharge-valve seats of the water end of the pump are worn, and most of them are, after being used a while. The water from the source of supply enters the pump cylinder, after passing up through the suction or intake valves. The top of the intake valves are subject to the discharge pressure in the pump, which lifts the discharge valves from their seats.

While one end *A* of the pump cylinder is discharging, the valve *B* is closed and the valve *C* is open. On the other end of the cylinder the position of the valves is reversed, and the valve *D* is open, admitting water to the end *F* of the cylinder, but the valve *E* is closed.

If the valves and seats are worn, water discharging from the end *A* of the cylinder will pass up through the discharge valve *C*, but some of the discharge water will be forced between the suction valve *B* and its seat into the intake passage and then down into the suction pipe, or up through the valve *D*, and into the end *F* of the cylinder. What water goes toward the suction pipe counteracts the upward movement of the water, due to the partial vacuum formed in the end *F*, of the pump cylinder. The amount of water entering the end *F*, from the end *A*, reduces the capacity of the pump just that much.

On the same stroke, water, under pressure, is being forced back between the valve *E*, and its seat, into the end *F* of the cylinder, which further reduces the capacity of the pump.

This is a condition present in most pumps to a greater or less degree, generally greater, because the engineers do not give the valve seats proper attention. There is no gain shown by skimping on the coal pile, working over time packing leaky pipe flanges and valve stems, etc., if the steam pumps are allowed to run in such a condition that they are consuming a great deal more steam than they should.

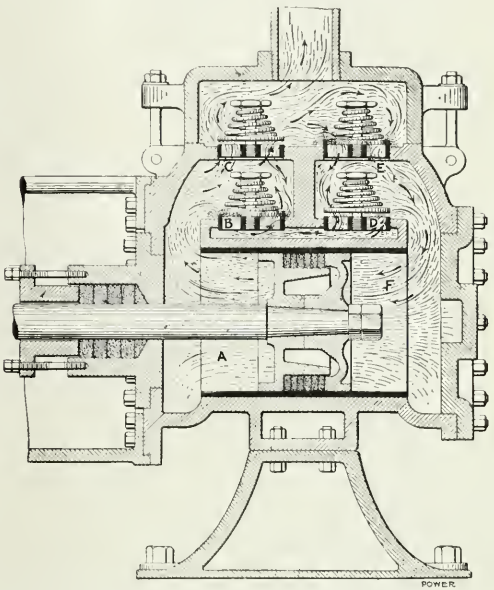
For instance, in one plant there were two compound, simplex pumps, operating at 25 r.p.m. One used 1000 lb. of steam per hr., the other pump nearly double the quantity, or 1800 lb., in doing the same work. The trouble was that the valves and valve seats on the wasteful pump were worn out of true.

One would suppose that the engineer of that plant would have suspected something was wrong with the wasteful pump, but not so. He was much like the engineer of another large plant. This man was a progressive, intelligent, uptodate engineer, who claimed he had never had any trouble with his pumps.

Something like a year ago a new heating system was put in and guaranteed to make a large saving in fuel, but the system did not come up to expectation. An investigation showed that the circulating pump was wasting a large amount of steam. The water-valve seats of the pump were refaced and the service was so improved that in half an hour after the pump was started the necessary amount of water had been supplied and the pump was stopped. The pump was working against 500 lb. pressure.

It is the procedure in several shops where pumps are manufactured to force the valve seats into place in new pumps. This may cause portions of the seat to bulge, making as many high spots on the valve face as there are bars. If bulging occurs it is just as necessary to reface the valve seats as if they were badly worn, which can easily be accomplished by a pump-valve reseating machine, made for the purpose, and which can be used without dismantling the pump.

Another instance can be cited where worn pump valves necessitated running two pumps, when one in proper condition could have supplied all of the water required. These pumps were each supplied with steam through a ¾-in. steam pipe. They were run about 75 strokes per minute to supply the required water. The manager finally decided to have the pump-valve seats faced true. After



Direction of Water Flow through Pump with Leaking Valves

one hour's work one pump was running at 18 strokes per minute, supplying all the water necessary, the other pump being idle.

In another instance a pump had been in use for 11 years. It had been condemned and a new one was to take its place. However, before it was discarded, the valve seats were machined and the pump put in serviceable condition, good for another 11 years' work, and, furthermore, saving in the neighborhood of $350 in the cost of a new pump.

As a last instance of many which could be cited, a pump, fed by a 1½-in. steam line, was run at a speed capable of supplying 615 boiler horsepower with feed water. After putting the valve seats in proper shape the speed of the pump was cut down about 65 per cent. of its former speed and is doing good work today.

Most engineers are willing to believe the worst that can be said about a neighboring plant, but cannot, or will not, see the shortcomings of their own. They can tell you all about the engine, its steam consumption and other data about the plant, but on the subject of the

steam pump, while admitting that they are steam eaters, they are silent. They do not know the actual condition of their pumps, for one thing, and because the pumps have been in use for years and have been able to keep the boilers supplied with feed water, it is assumed that the internal parts are in good shape and further consideration of their economical operation is neglected. The pumps, therefore, are run at a faster speed than they should, to supply the necessary water, and the owner pays the excess fuel bill because of excessive steam consumption.

Shop Demonstration of Water Flow in National Heater

In order to set at rest any misconceptions regarding the actual flow of water in a National direct-contact heater, a demonstration was made in the shops of the makers, The National Pipe Bending Co., New Haven, Conn. As the flow of water could be seen only by making one side of the heater of glass, one side of the heater was removed and a glass plate substituted, sufficiently large to come well above the water line, thus inclosing the lower part of the heater in which the water is retained. Water was allowed to flow through the heater at the rate of 850 hp. capacity per hr., the heater having a capacity of 1000 hp. A description of this type of heater was published on page 714, May 14 of last year.

The Use of Economizers*

The speaker first described with the aid of illustrations the dependence of chimney costs upon their height and upper inside diameter, the relations between the chimney height, the hourly consumption of fuel and the operating costs and the temperature of the gases entering the chimney.

Of great importance in determining the gross dimensions of the economizer, are the temperature of the entering water and the drop in temperature of the flue gases that are employed.

The entire installation will be cheapest when the utilization of the flue gases in the economizer goes the farthest. How far the flue-gas temperature is then economically utilized depends upon the temperature of the feed water. Assuming a uniform load, the most economical plant for low feed-water temperatures corresponds to a chimney temperature of 266 to 284 deg. F.; for average feed-water temperatures, 338 deg., and for high feed-water temperatures, 392 deg. If the service is variable it is proper to proportion the outfit for the average efficiency.

The question whether in large plants one common economizer or separate equipments behind each boiler should be used cannot be settled by general principles since it depends upon working conditions. With very regular load a common economizer would be advantageous because of its cheaper first cost and its smaller radiating surface, while where boilers are frequently cut off, as in electrical stations, individual economizers are preferable, there being danger that otherwise a too great cooling down of the flue gases may reduce the draft and also that the tubes will be fouled.

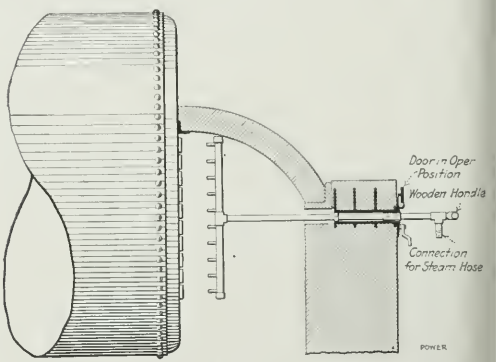
Summing up, the question of employing economizers may be answered by saying that they are primarily of use in enabling the designer to lay down an economical plant, by most completely utilizing the flue gases and obtaining the best combustion. Their field of usefulness will widen the more that small boiler plants disappear and hand stoking gives place to mechanical. The size of an economizer as compared with the boiler-heating surface—which cannot be settled by a fixed ratio, since it depends upon the feed-water temperature—should increase with the pressure and with increased attempt to employ in the boiler itself only heating surfaces of high value.

*Abstract of a report by Engineer Gleichmann, presented at the Munich convention of the International Association of Steam Boiler Inspection Societies. Translated from "Glückauf."

Myers Improved Boiler-Tube Blower

A new tube blower for horizontal, return-tubular boilers has been developed, and has successfully weathered two years of strenuous testing. It is impossible for the tube blower to burn out or deteriorate in the hot gases, because when not in use it is withdrawn bodily from the boiler setting.

The design is such that each individual boiler tube received a single powerful jet of steam at its exact center. There is, therefore, no turning of the steam through an angle or the dissipating of its force by passing it through the 2 ft. of hot gases in the rear combustion chamber. Therefore, a powerful cleaning effect is produced on the inside surface of the tubes with a minimum amount of steam. As the blower is removable, one blower can serve any number of boilers, provided they have the same tube spacing, each boiler being provided with the cast-iron slot door for the insertion and withdrawal of the blower.



TUBE BLOWER IN POSITION FOR BLOWING TUBES

The blower part consists essentially of a tee, formed of standard steam pipe with nipples on the cross piece, which act as steam jets. These jets are specially designed and interchangeable with other jets with different-size nozzles, making them adaptable to any set of local conditions that may be found, as to steam pressure and size of boiler tubes.

The blower portion is fitted with a wooden handle and a hose connection to which the hose, preferably a flexible brass one, is attached. The steam connection for the blower should be made near the center of a pair or battery of boilers at their rear; thus the blower can be taken

in either direction without disconnecting to clean the tubes of either boiler.

The other part of this device consists of a cast-iron slotted door, set horizontally in the rear wall of the boiler setting, exactly opposite the middle row of tubes, as shown in the illustration, where the blower is inserted through the slotted door in its operating position ready for cleaning the tubes.

The operation of cleaning a boiler consists of opening the door covering the slot in the rear of the boiler and inserting the blower. Then the blower head is turned through an angle of 90 deg. and the guide block is slipped up into position in the slot in which it has a sliding fit. This guide block holds the blower head containing the nozzles in alignment with any vertical row of tubes in the boiler. The blower is then slid along this slot opposite the left-hand row of tubes, then to the right to the next row, and so on until each vertical row of tubes has been thoroughly cleaned, the jets of the blower acting in perfect axial alignment with the individual tubes. After cleaning the tubes the blower is again removed by turning 90 deg., and is then pulled out of the slot. It was invented and patented by David Moffat Myers, 17 Battery Place, New York City.

Autogenously Welded Flywheel

A flywheel which has been welded in four places is shown in the illustration. The work was done at the No. 2 mill of the American Thread Co., at Holyoke, Mass., by THE Welding Co.

While the engine was being moved from one of the mills the flywheel was dropped, breaking one spoke out entirely and cracking two others. It was found that a new wheel would cost $1800, and there would be a considerable delay which would add very largely to this cost.

Welding Broken Flywheel

The welding was undertaken under a guarantee of no charge if not successful.

The repair was completed in one day. The welding was performed without turning the wheel over, it being, however, welded from both sides. It was a somewhat remarkable performance to weld these spokes from the underside as this is an exceedingly difficult operation on gray iron.

When the wheel was put into operation again it was found to be true within a reasonable degree being not more out of round than such large wheels are apt to be in ordinary operation.

The welds were tested by jarring the spokes before putting the wheel in commission, and the engine was then run at an excess speed without the belt to test the welds.

Pumping Plants of the Western Water Co.

Prompted by the urgent need of the oil fields, C. B. Colby, Bakersfield, Calif., recently organized a corporation to supply water for boilers, oil-well drilling and domestic purposes, to the California Midway oil field, the largest in the world.

This field was at that time being supplied with boiler and drilling water from deep wells which contained so much sulphur and salt that it could not be used for domestic purposes, and domestic water was transported in tank cars 48 miles and sold in the fields for 20c. a bbl.

Because of these conditions several unsuccessful attempts were made to supply the field with additional water, one notable among them being a plan to bring water down from the mountains on the south, a distance of about 40 miles through a pipe line. This was abandoned on account of its engineering difficulties, which made the cost almost prohibitive.

The problem was solved by drilling a well near where the Kern River turns to run into a lake, about 12 miles from the oil fields. It was pumped continuously for six days to establish, without a doubt, the quantity and quality of the water which was found suitable for both domestic and boiler purposes.

A corporation known as the Western Water Co. was organized and plans were made to install pumping machinery of sufficient size to pump 2,000,000 gal. per day to a storage tank on the highest hill in the field and distribute the water by gravitation.

The pipe line is made with couplings, consisting of a body ring and two ring flanges, through which bolts are fitted, and when drawn up compress a ring of packing against the outside surface of the pipe, thus making a water-tight joint. The use of this type of coupling facilitates repairs in case of leakage or damage to a pipe line, due to washouts, caused by heavy rains in the hills.

One of the pumping plants consists of two No. 7 Layne & Bowler vertical turbine pumps; the capacity of each is about 2,000,000 gal. per day. These two pumps are driven by one 50-hp., single-cylinder, horizontal-type engine for the pump in well No. 5 and one 80-hp., three-cylinder, vertical, heavy-duty gas engine, for the pump in well No. 7.

The elevation at the surface of the ground where these pumps are installed is 297 ft. above sea level. When not being pumped, the water in the wells rises and runs over the top of the casing. When being pumped to the full capacity of the pumps, the water is lowered only about 58 ft.

The water from these pumps is discharged into two 10-in. pipes which connect to Y-branches on the 14-in. discharge line leading to a concrete reservoir 672 ft. distant.

The reservoir is 40x100 ft. by 5½ ft. deep, divided into two basins 40x50 ft., so that one side can be emptied and cleaned, without interrupting the water supply.

The water first enters a small box or settling basin be-

fore flowing into the reservoir, which prevents sand and silt from entering the 20-in. suction pipe leading to the 9x18-in. power pumps in the main building. The elevation of the floor of this building is 310 ft. 6 in. Water is thus supplied to the pumps, under slight pressure.

The equipment in the main building consists of three 9x8-in. pot-valve power pumps, direct connected to three 250-hp. four-cylinder engines, operating on natural gas.

The pumps are fitted with 10-in. discharge pipes which connect to the Y-branch fittings in the 12-in. main line.

Each pump is fitted with a relief valve set at 550 lb. pressure. The line pressure when a plant is in operation being from 500 to 525 lb. per sq.in., 300 lb. of which is static and 200 to 225 lb. is caused by friction in the pipe. There are also four alleviations on the main line at this point to take care of any water-hammer that may occur.

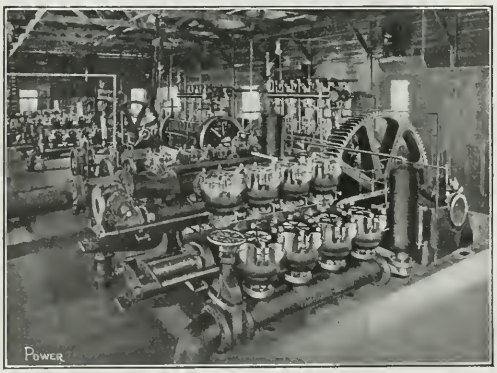
All Y-branches, gates and other fittings were placed in the pipe line and tested to 1000 lb. per sq.in. hydraulic pressure.

The main building, 50x95 ft., is a substantial frame structure, covered with corrugated iron. The roof trusses are built to carry a load of two tons on the traveling crane, which is fastened to them. The crane was provided for the handling of heavy pump and engine castings, if necessary. The floors are concrete.

The average consumption of gas per month is 5,500,000 cu.ft. Lubricating oil consumed averages 200 gal. per month. The oil is pumped from the crank case of the engines to filters, and from there gravitated to the tanks that supply the oiling system.

For auxiliary equipment there is an electric-lighting plant to light all of the buildings, the engine of the light equipment also drives an air compressor which charges three receiving tanks.

The compressed air is used for starting the large engines and by its use any one of the 250-hp. engines can be easily started by a single operator.



THREE 250-HP. GAS ENGINES DIRECTLY CONNECTED TO THREE 9X18-IN. POWER PUMPS

There is also a refrigerating plant of one ton capacity, a machine shop containing a lathe, drill press and pipe-threading machine, etc.; a blacksmith shop and a garage, also an oil house, where all waste oil is collected and filtered, and a heavy press for squeezing the oil out of wiping rags.

Station No. 2 receives the water coming through the 12-in. line from station No. 1 in a 5000-bbl. tank near the power house.

The machinery in station No. 2 consists of three 100-hp. horizontal-tubular boilers and three temporary 40-hp. firebox boilers, one 18x6x18-in. Coalinga pattern pump, and two 18x18½x18-in. duplex pot-valve pumps. The fuel used at this plant is natural gas and amounts to about 6,000,000 cu.ft. per month. This station is also equipped with a 6½x8-in. triplex power pump driven by a 50-hp. induction motor.

Water is discharged from the large line pumps in this station into a 12-in. manifold to which is connected the 8-in. line, which discharges the water into the 55,000-bbl. storage tank, a distance of two miles.

A feature in connection with the operation of the system is that no trouble has been experienced with either machinery or pipe line. The 250-hp. gas engines at station No. 1 have operated continuously on an average of twenty-six 24-hr. days a month for 20 months, and the 50-hp. single-cylinder engine pulled a load amounting to 60 hp. for a period of 10 months. The gas engines and pumps other than those mentioned were built by the Fairbanks-Morse Co.

The Western Water Co. supplies water to approximately 60 per cent. of the Midway-Sunset oil fields, or a total of 30,720 acres of oil land. The water is sold at 3c. a bbl., whereas heretofore operators have paid from 6c. to 20c. per bbl. At the present time 35,000 bbl. of 42 gal. each are being delivered daily.

Bill B. Banger on Boiler Explosions

BY BILL B. BANGER

When a feller's got things on his mind th' best thing t' do is t' get um outer th' way as soon as possible and that's what I'm goin' t' do. Some fellers can sleep over a live volcano and don't seem t' know it's there. When I speak of volcanoes I mean some of these dinged lap joint steam bilers what has been in service a quarter o a century, more or less, and th' worst part of it is tha innocent people, what don't know th' difference betwee a biler and a sausage are riskin' their lives and legs ever day in th' year, except perhaps Sundays, and are so gla they have a job they think they are favored by Providence and By Heck they are, for if it wasn't for th' care o some sich thing most of um would have attended thei own funeral long ago.

When the engineerin' papers can spout about so man biler bustups and show pictures of um t' boot, a tellin how th' thing happened and sometimes wonderin' why didn't bust before, it makes a feller want t' ease up on th steam pressure and wonder how many cracks there ar under th' lap joint of th' biler he is nursin'.

When a biler goes t' smash there's usually a good rea son for it and th' first thing a feller wants t' know what was th' cause, and why did there domn thing do s much damage. From th' little experience I have ha with biler explosions, th' cause is easy t' find, provide th' company ownin' th' biler will let a feller in t' examin th' remains. It's easy enough t' trace an old crack, or detect signs of a burnt biler, and th' state of th' shee and tubes gives a pretty good idea as t' how th' biler h been taken care of.

Generally th' cuss of an engineer gets th' blame f

n accident t' a biler, and as he can't talk back in most ases, he goes t' his grave, kind of dishonored like, and eckoned for a time among th' town folk as havin' brought n his own destruction; at th' same time his memory is ursed by th' relatives of th' men killed with him and he as t' carry the hatred of those who happened t' be in- ired in th' racket t' his silent grave.

'Th' humble opinion of your Uncle Bill is that some- in' is wrong. Of course, an engineer should be a care-

As I Looked at th' Wreckage, I Calculated Some- thin' Must of Let Go Unexpected Like."

il man and he should not allow a biler t' be operated in n unsafe condition, as has been said several hundred mes before, but th' engineer ain't th' only nigger in th' oal pile, not by a tadpole. It's easy enough t' blame t' engineer, but what's th' matter with turnin' th' search ght on th' owner of th' biler what blew up and see what ind of an excuse he'll spring for operatin' a biler what ommon sense would tell a half-baked pippin was only t for old junk and at a cheap price at that?

Th' Good Book says somewhere, I think, "come let us ason t'gether," and it won't do us a mite of harm t' do t' same. I'll be willin' t' bet seven cents, if I can find ny takers, that there ain't one man in 1000 what would ut in an engine, feed pump, or even an oil filter and ex- ect any one of um to last from 20 to 25 years without epairs, but at th' same time most of um would put in a issed lap-joint biler and kick if th' engineer asked for new handhole crab, fer th' back end of th' biler, inside f ten years.

'Tain't no uncommon thing t' go int' a biler room and ave th' engineer hitch up his pants and throw out his nest and tell you th' biler ain't had a cent's worth of re- airs since it was put in service 20 years ago, and that was a second-hand biler at that time, so nobody knows ist how old th' old kettle is. It ain't much to brag about my mind and it's a pretty sure thing that if a biler as been heated up and cooled twice a day for 20 or 25 ears it is about time somethin' was done with it, if it's othin' mor'n givin' it a dose of th' hydrostatic test. I kind of calculate that most bilers of uncertain age would bust a gizzard or somethin' of the sort and by th' pro- cedure prolong th' lives of several prospective victims.

I don't know why some insurance and inspection com- panies don't look int' these matters more closely. Of course, insurin' bilers is more or less of a gamble on th' part of both parties. Th' owner takes th' side that th' biler is likely t' blow up and is willin' t' bet th' insurance company a certain sum that it will. If th' biler holds together th' owner is out th' amount of th' premium. On th' other hand, th' insurance company gambles that th biler won't bust and bets th' owner th' amount of dam- age t' property against th' premium that it won't. Th' insurance company wins most times, or it would soon go out of business, but on th' other hand, there is th' tempta- tion t' run a risk on an uncertain biler just a little longer. I won't come out flat footed and say that this is th' case, but things what has come t' my attention of late years lead me t' suspect that it is so.

I was told by a feller, what knows, that one of th' bilers what exploded recently had been carried by one insurance company and they had dropped th' risk like a hot iron; it was refused by another and was then taken up by a third company. Now, if that is so, what protection does biler insurance give mor'n that it insures th' owner against loss of property in case th' dinged biler does ex- plode? It don't protect him against damage suits due t' killed and injured pepole what had nothin' t' do with th' biler. I take it that most biler owners don't take this last proposition int' consideration until it is t' late

Of course, th' biler is inspected shipshape at certain periods, if the inspector gets a chance t' get int' it. But if th' owner won't get it ready fer inspection, I don't see where th' insurance company comes in. T' be sure they can make an external inspection, but that don't give much assurance that th' biler is all right, By Heck, especially when th' way things are managed around th' plant is such as t' make a contidin' poodle dog suspicious.

If th' owner of a biler gets it insured and then refuses t' have repairs made as recommended by th' inspector, or refuse t' let th' inspector get int' th' dinged biler it looks as if all that was wanted was th' protection against damage in case th' biler did go t' smash. Th' safety of th' men seems t' be a secondary consideration in the es- timation of some biler owners.

Now yer Uncle Bill believes in biler inspection and in- surance when it's carried on with common sense, but there ain't any sense for one company t' insure a biler after another has canceled th' risk because of th' condi- tion it was in or because of th' abuse it was gittin'. It ain't honest business no matter how yer look at it, and there ain't any more sense t' it then t' eat beef steak that's so tough yer can't stick yer fork in th' gravy, when yer can get somethin' tender fer th' askin'.

Safety first, profits next, would be a good motto fer all concerned t' adopt when monkeyin' with steam bilers.

Big Men start by firing up their imagination, and then they throw over the lever of will power, and the machinery moves. Imagination is the fire under the boiler. Will power is the steam in the boiler. Big minds and big ma- chinery are moved much in the same manner. A small man has little imagination; naturally, never gets up much fire. The bigger the imagination, the more the horsepower. The more the will power—the more the results. Dream and work.—"The Silent Partner."

Standard Tubular-Boiler Specifications

The National Association of Tubular Boiler Manufacturers has recently issued a set of specifications covering fire-tube boilers and 34 individuals and companies who are members of the association have approved and adopted it. The principal features are as follows:

MATERIALS

The shell, heads and covering strips of the standard boiler shall be of flange steel as described in the standard specifications of the Association of American Steel Manufacturers. All such plates shall be marked 60,000 lb. tensile strength and in building the boiler the plates shall be so placed that these stamps are plainly visible on the outside. These plates shall have the full specified thickness at the edges and shall meet the tensile, quenching and bend tests described.

The tubes shall be standard quality lap welded mild steel of standard manufacture. The thickness of the metal shall be 12 B.w.g. for 3-in. tubes, 11 B.w.g. for 3½-in. tubes and 10 B.w.g. for 4-in. tubes.

The rivets shall be of boiler-rivet steel as described in the standard specifications of the Association of American

TABLE 1. DIMENSIONS FOR STANDARD RETURN-TUBULAR BOILERS

	Horsepower of Boiler as Rated	Diameter of Boiler, In.	Length of Tubes, Ft.	Number of 3½-in. Tubes	Number of 4-in. Tubes	Tube Heating Surface with 3½-in. Tubes, Sq.Ft.	Tube Heating Surface with 4-in. Tubes, Sq.Ft.	Shell Heating Surface Sq.Ft.	Thickness of Shell, In.	Thickness of Heads, In.	Width of Grates, In.	Length of Grates, In.	Area of Grates, Sq.Ft.	Diameter of Stack, In.	Length of Stack, Ft.	Gage of Stack	Length of Guys, Ft.	Diameter of Guys, In.	Size of Steam Opening, In.	Size of Pop Safety Valve, In.	Size of Water Gage Glass, In.	Size of Water Column Connections, In.	Size of Gage Cocks, In.	Size of Blow-off, In.	Size of Feed and Check Valves, In.	Size of Steam Gage Dial, In.
100 lb. Working Pressure — Longitudinal Seams, All Butt Jointed — Double Riveted	70	54	16	44	36	645.1	603.2	150.8	5/16	7/16	54	54	20.25	26	60	16	600	1/2	3½	2½	1	1¼	1	2	1¼	5
	80	60	16	54	44	791.7	737.2	167.6	5/16	7/16	60	54	22 5	28	60	14	600	1/2	4	2½	1	1¼	1	2	1¼	5
	90	60	18	54	44	890.6	829.4	188.5	5/16	7/16	60	60	25.0	28	60	14	600	1/2	5	3	1	1¼	1	2	1¼	5
	100	66	16	66	54	967.6	904.8	184.3	11/32	7/16	66	54	24.75	30	60	14	600	1/2	5	3	1	1½	1	2	1½	5
	110	66	18	66	54	1088.6	1017.9	207.4	11/32	7/16	66	60	27.5	30	60	14	600	1/2	5	3	1	1½	1	2	1½	5
	125	72	16	86	70	1260.8	1172.9	201.1	3/8	1/2	72	54	27.0	34	60	14	600	1/2	5	4	1	1½	1	2	1½	5
	150	72	18	86	70	1418.4	1319.5	226.2	3/8	1/2	72	60	30.0	34	60	14	600	1/2	6	4	1	1½	1	2½	1½	5
	165	72	20	86	70	1576.0	1466.0	251.3	3/8	1/2	72	66	33.0	34	70	14	700	1/2	6	4	1	1½	1	2½	1½	5
	180	78	18	110	88	1814.0	1658.8	245.2	7/16	9/16	78	60	32.5	38	60	12	600	1/2	6	4	1	1½	1	2½	2	5
	200	78	20	110	88	2015.9	1843.1	272.4	7/16	9/16	78	66	35.75	38	70	12	700	1/2	6	4	1	1½	1	2½	2	5
125 lb. Working Pressure — Longitudinal Seams, All Butt Jointed — Triple Riveted	70	54	16	44	36	645.1	603 2	150.8	11/32	7/16	54	54	20 25	26	60	16	600	1/2	3½	2½	1	1¼	1	2	1¼	5
	80	60	16	54	44	791.7	737.2	167.6	3/8	1/2	60	54	22 5	28	60	14	600	1/2	4	2½	1	1¼	1	2	1¼	5
	90	60	18	54	44	890.6	829.4	188.5	3/8	1/2	60	60	25.0	28	60	14	600	1/2	5	3	1	1¼	1	2	1¼	5
	100	66	16	66	54	967.6	904.8	184 3	13/32	1/2	66	54	24.75	30	60	14	600	1/2	5	3	1	1½	1	2	1½	5
	110	66	18	66	54	1088.6	1017.9	207.4	13/32	1/2	66	60	27.5	30	60	14	600	1/2	5	3	1	1½	1	2	1½	5
	125	72	16	86	70	1260.8	1172 9	201.1	7/16	9/16	72	54	27.0	34	60	14	600	1/2	5	4	1	1½	1	2	1½	5
	150	72	18	86	70	1418.4	1319.5	226.2	7/16	9/16	72	60	30.0	34	60	14	600	1/2	6	4	1	1½	1	2½	1½	5
	165	72	20	86	70	1576.0	1466.0	251.3	7/16	9/16	72	66	33 0	34	70	14	700	1/2	6	4	1	1½	1	2½	1½	5
	180	78	18	110	88	1814 0	1658.8	245 2	1/2	5/8	78	60	32 5	38	60	12	600	1/2	6	4	1	1½	1	2½	2	5
	200	78	20	110	88	2015.9	1843.1	272.4	1/2	5/8	78	66	35.75	38	70	12	700	1/2	6	4	1	1½	1	2½	2	5
150 lb. Working Pressure — Longitudinal Seams, All Butt Jointed — Quadruple Riveted	70	54	16	44	36	645.1	603 2	150.8	3/8	7/16	54	54	20.25	26	60	16	600	1/2	3½	2½	1	1¼	1	2	1¼	5
	80	60	16	54	44	791.7	737.2	167.6	13/32	1/2	60	54	22.5	28	60	14	600	1/2	4	2½	1	1¼	1	2	1¼	5
	90	60	18	54	44	890.6	829.4	188.5	13/32	1/2	60	60	25 0	28	60	14	600	1/2	5	3	1	1¼	1	2	1¼	5
	100	66	16	66	54	967.6	904.8	184.3	13/32	1/2	66	54	24 75	30	60	14	600	1/2	5	3	1	1½	1	2	1½	5
	110	66	18	66	54	1088.6	1017.9	207.4	13/32	1/2	66	60	27 5	30	60	14	600	1/2	5	3	1	1½	1	2	1½	5
	125	72	16	86	70	1260.8	1172.9	201.1	7/16	9/16	72	54	27.0	34	60	14	600	1/2	5	4	1	1½	1	2	1½	5
	150	72	18	86	70	1418.4	1319.5	226.2	7/16	9/16	72	60	30.0	34	60	14	600	1/2	6	4	1	1½	1	2½	1½	5
	165	72	20	86	70	1576.0	1466.0	251.3	7/16	9/16	72	66	33.0	34	70	14	700	1/2	6	4	1	1½	1	2½	1½	5
	180	78	18	110	88	1814 0	1658.8	245.2	1/2	5/8	78	60	32.5	38	60	12	600	1/2	6	4	1	1½	1	2½	2	5
	200	78	20	110	88	2015.9	1843.1	272.4	1/2	5/8	78	66	35.75	38	70	12	700	1/2	6	4	1	1½	1	2½	2	5

Size of Trimmings

either double, triple or quadruple riveted as indicated in Table 1*.

The circumferential seams shall be of the lap type of joint and single riveted.

In all joints the size, number and spacing of the rivets shall be such as to provide the strength necessary to maintain the factor of safety of five.

The tubes shall be placed in vertical and horizontal rows with ample space between the adjacent tubes and also between tubes and shell for the circulation of water and also with a large steam space above the water line.

Boilers 44 in. or less in diameter shall have a manhole above the tubes and a handhole below the tubes. These may both be in the front head or the handhole may be in the front head and the manhole in the back head. Boilers 48 in. in diameter shall have two manholes, both in the heads, one above the tubes and one below the tubes. They may both be in the front head or one manhole may be in the front head below the tubes and the other in the back head above the tubes. Boilers larger than 48 in. shall have two manholes, one of which shall be in the front end below the tubes, the other shall be above the tubes in either head or preferably may be placed in the shell.

The opening in the manhole shall not be less than 10x15 in. Each manhole shall be equipped with a heavy plate, bale, bolt, nut and gasket.

Steel Manufacturers and of proper size to suit the size of the hole and the thickness of the plates and to form up heads equal in strength to the pressed heads of same.

The diagonal braces shall be weldless of the same quality as the flange steel previously described and pressed from the solid plate, or else forged from steel bars. The number of braces to be used shall be computed on an allowance of not more than 7500 lb. of load per square inch of section of brace neglecting, in this, the inherent strength of the heads and the slight angularity of the braces.

Suitable through rods and braces shall be installed below the tubes when necessary to sustain the pressure. These shall be of steel and shall be computed with the same allowance as diagonal braces.

Braces as above described shall be carefully placed so that the pressure on the flat surfaces, both above and below the tubes, shall be as nearly equally distributed as possible.

For any boiler head the area to be supported by braces shall be the surface included within lines drawn 2 in. from the outside of the tubes and 3 in. from the inside of the shell.

DESIGN

The longitudinal seam of the shell shall be of the butt-joint type having inside and outside covering strips and

Manholes placed in the shell shall be properly reinforced with a suitable steel saddle.

All openings 2 in. in diameter or larger shall have suitable steel reinforcing flanges riveted on. Cast-iron flanges or nozzles shall not be used.

Boilers for 125 to 150 lb. working pressure shall have the feed opening in the front head over the tubes and same shall be provided with a brass bushing and an internal feed pipe extending from the front end of the boiler to within about 3 ft. of the rear head, thence across to the side of the shell terminating in an elbow for discharge below the top row of tubes.

*The butt type of joint is specified because the lap joint has been proved dangerous when used for the longitudinal seams. Defects in the lap seam usually develop where the parts are hidden. Inspection cannot reveal them. Domes are not specified because they are mechanically bad and are not necessary. The fixed, or "plug hat" type of dome is awkward at best, it tends to weaken the boiler and frequently makes the use of the lap type of joint necessary on the longitudinal seam.

The independent type of dome can be used on any boiler, but it will probably be found to be better engineering to apply it in the form of a steam separator near the engine throttle instead of as a dome near the boiler.

The manufacturers who have adopted these specifications do not recommend domes, or lap joints when used on longitudinal seams.

Boilers for 100 lb. working pressure shall be arranged to through the blowoff connection and the internal feed be omitted.

Each boiler shall he provided with four steel lugs or kets, two on each side for supporting the boiler, except boilers 78 in. in diameter or boilers 20 ft. long shall be vided with eight such lugs, four on each side of the er and all of them arranged in pairs.

WORKMANSHIP

All rivet holes, and all tube holes shall be either drilled n the solid or punched small and reamed to size. After ling or reaming the plates shall be taken apart and all rs removed and the tube holes chamfered with a rose mer.

The edges of the plates shall be beveled to an accurate lking edge and after being riveted shall be caulked tight h a round nose tool.

The tubes shall be carefully placed, expanded tight in heads with a roller expander and the ends carefully ded over against the head at both ends.

WATER COLUMN

The water column shall be provided with three gage-ks and shall be so placed that the lowest gage-cock ll be 2 in. above the tops of the uppermost row of es. The middle gage-cock shall be 3 in. and the upper-st gage-cock 6 in. above the lowest gage-cock measured tically.

TESTS

All material used in the construction of the boiler shall rigidly tested as called for in the above specifications and completed boiler shall be subjected to a steady water ssure 50 per cent. above its proposed working pressure l made tight.

When specially requested the boiler manufacturer will nish copies of the record of tests of the plates as made the steel manufacturers. These reports shall be deemed ficient indication of the quality of steel used.

EQUIPMENT

A complete standard boiler equipment includes: The bare ler with lugs; cast-iron front with anchors; grate bars th bearers; rear arch bars; rear ashpit door and frame; ety valve with nipple to connect it to boiler; steam gage th siphon; water column with gage-glass, three gage-ks and pipe connections to boiler; blowoff valve; check ve; stop valve for water feed line; smoke stack and ys; stacks less than 60 ft. long shall have four guy eyes, l guys six times as long as the stacks. Stacks 60 ft. g or longer shall have six guy eyes, two sets of three, and ys ten times as long as the stack. A stack plate or nozzle ll be included with each full-front boiler.

Of course, where boilers built according to the fore-ing specifications are not legally satisfactory necessary odification is made.

Minimizing the Damage

A short time ago a tube burst on a 550-hp. Stirling iler, writes J. A. Fritz in the American Gas & Electric o.'s *Bulletin,* and while it did no great damage, it might terest the readers to know what means we are taking minimize the damage, should a like accident occur.

This boiler was equipped with Babcock & Wilcox bal-nced fire-doors swinging inward. The tube that burst as in the row next to the fire, and while the automatic op and check valve on the boiler operated at once, the caping steam from the burst tube built up sufficient essure inside the walls of the boiler setting to blow own the first baffle wall and bulge out the front of the iler about 3 in. At the same time it blew off about lf of the bricks on top of the boiler, which relieved the essure and the damage was stopped. Luckily no one as hurt as the fireman had just stepped to one side of e boiler and the escaping steam and water around the re-doors did not reach him.

When we rebricked the setting we left a hole about 3 . square on the top of the boiler, which we covered with a ¼-in. plate with a layer of asbestos on it. This being light will lift readily, relieve the pressure, and save the setting in the event of another occurrence of a similar nature.

We intend to equip all our boilers in this way, as we feel that an explosion door of some kind is necessary when the fire-doors open inwardly (which is the only way any fire-door should open) as it can readily be seen that the more nearly equal in strength the walls of the setting may be, the more severe will be the damage.

The result of this explosion emphasizes another fact, that all boilers should be equipped with stop and check valves, as in this case the hole blown in the top of the boiler setting was just where a man would have to stand to shut off the stop valve to the boiler. Had the automatic valve not operated he could not have closed the other valve and this might have meant a complete shutdown, as a pressure of 150 lb. blowing to the atmosphere through a 3¼-in. hole would soon fill a boiler room so full of steam that it would be impossible to get to any valves on the boilers, especially if the boiler house had a low roof.

"Kwikgrip" Pipe Wrench

This wrench differs from others, in that it is made with a straight, tempered jaw of vanadium steel. As indicated, the toothed jaw is in alignment with the handle and, therefore, is in line with the force of application. The smooth jaw is at an angle from the handle and receives the entire impact of the force of application and, by reacting from the smooth jaw the full force of the impact is forced to the teeth which locks the wrench to the pipe.

KWIKGRIP PIPE WRENCH

The steel teeth are graduated and are made of the proper size to fit various sizes of pipe. The large teeth are in the outer end of the jaw for gripping large pipes, and small teeth, at the inner end of the jaw, for small pipes.

The point of application of the toothed jaw is at the top center of the pipe, as shown. This is also the pivoting point of the turning force and as the handle is in alignment with the toothed jaw, the greater turning force applied to the handle the more firmly the teeth grip the pipe.

This wrench is made in seven sizes by the Prince-Groff Co., 18-22 George St., Camden, N. J. It is easily applied to the pipe in any position and the tempered teeth stay sharp for a long time.

Increased Use of Locomotive Superheaters—There was recently held at Cassel-Wilhelmshöhe a celebration to commemorate the equipment of the 25,000th locomotive with the Schmidt system of superheating, which has now become a standard and increasingly popular feature of locomotive practice. Dr. Schmidt's first superheater to be applied to locomotives was installed in 1898 on some engines of the Prussian State Rys. Schmidt's pioneer work and its success encouraged competition.

ELECTRICAL DEPARTMENT

Current Rectifiers

By John A. Randolph

There are, in general, six types of apparatus used for converting alternating current into direct, namely; the rotary converter, the motor-generator, the rectifying commutator, the aluminum-valve rectifier, the vibratory type and the mercury-arc rectifier. The most widely used of these are the rotary converter, the motor-generator and the mercury-arc rectifier. The others are more or less limited in their application, hence are not so generally employed.

The rotary converter and the motor-generator are the machines most commonly used for the conversion of currents in large quantities. The former is generally employed, but the latter is preferable under certain conditions. One advantage which the motor-generator possesses, when its motor is of the induction type, is its continuity of operation under fluctuations of voltage. It will continue to operate safely on a variable alternating-current pressure with little necessity for attention on the part of the operator. Moreover, if the power supply should be momentarily interrupted and return quickly, the motor will at once take up its work again without causing the inconvenience of a special starting procedure. The rotary converter, on the other hand, being a synchronous machine, may fall out of step, under such a contingency, and thereby require the time and inconvenience incident to synchronizing again before it can continue its operation.

Another advantage of the motor-generator is its independent direct-current voltage control. The direct-current end of the machine being entirely separate electrically from the alternating-current end, the direct-current voltage may be varied at will without recourse to a corresponding variation in the alternating-current pressure. Also, it possesses an advantage in that, by the use of a high-voltage motor, it may be connected directly to a high-tension supply without the use of transformers.

Under the conditions most commonly encountered, however, the rotary converter is much to be preferred to the motor-generator. In the first place, its first cost is lower and its efficiency higher in that it consists of but one machine instead of two. Moreover, the floor space which it occupies is smaller. The moving parts and windings are less in number, thereby rendering repairing and renewals less frequent. The general attention required is also less on account of its compactness.

Rectifying Commutator

This method, shown in Fig. 1, is used principally in connection with composite field excitation of alternators. In this case the commutator is mounted on an extension of the armature shaft. If separately driven it must be at a speed synchronous with the alternating-current supply. The number of segments corresponds to the number of field poles of the alternator. All segments of even number are connected together as are also the odd-numbered segments. From one of these common connections a lead is run to the armature circuit and from the other to one of the slip rings, as shown. The two brushes are so spaced that one makes contact with an odd-numbered

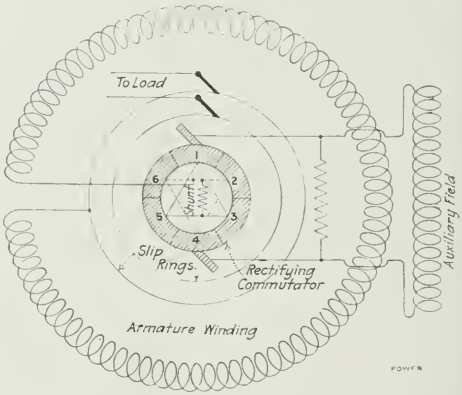


Fig. 1. Connections for Rectifying Commutator

segment at the same time that the other is bearing upon a segment of even number. The commutator moves forward one space or segment with each reversal of current following the movement of the armature coils from pole to pole. This causes each commutator brush to bear alternately upon the two sets of segments, in synchronism with the reversal of current in the armature. By tracing the current flow, it will be seen that the current passing through the circuit leading from the commutator brushes can flow in but one direction. A shunt can be used in case it is desired to rectify but a part of the current.

Aluminum-Valve Rectifier

This type makes use of the principle that aluminum plates or electrodes in certain solutions will allow current to pass through them in but one direction, namely, inwardly from the solution. The aluminum plates can therefore be used only as cathodes or negative plates to which the current flows within the rectifier. Two aluminum electrodes and one of iron are immersed in a neutral solution of ammonium phosphate, as shown in Fig. 2. The iron plate comprises the anode or positive plate from which the current flows within the rectifier. The cathodes are each connected to a terminal of a transformer while the iron anode is connected to one terminal of the battery to be charged. The other battery terminal is connected to the middle point of an auto-transformer connected across the two secondary leads from the supply transformer, as shown. At a moment when the terminal A of the supply transformer is positive, the current will flow as shown by the solid arrows. The cathode C' will not allow current to flow through it in this direction be-

use of a film of aluminum oxide on its surface which p to a pressure of 150 volts offers a very high resistance currents tending to flow in this direction. The current, therefore, flows to the point E where it is forced ward the battery, owing to the fact that the other half of the auto-transformer, acting as the secondary of a ransformer of which the coil G is the primary, establishes pressure acting toward the point E which prevents the urrent from flowing beyond E and through the coil H. oreover, the coil H sets up a current toward E which is f the same magnitude as that in coil G and is added to . The combined currents flow through the battery to he iron anode, thence to the cathode D from which they ow to the terminal F of the auto-transformer where the ortion supplied by coil H is diverted to the coil to comlete its circuit. The main current continues to terminal of the supply transformer.

In the next half period, when the direction of current n the supply mains is reversed, the path through the ectifier and battery will be as shown by the dotted arows. The plate C now becomes the active cathode.

This type of rectifier is limited on the direct-current ide to a voltage of approximately 55 and a current of bout 25 amp., owing to the heating tendency of the cell. t also has a disadvantage in that its efficiency is low. On ccount of its limitations and comparatively high cost f operation, it has not come into general use.

The Vibratory Rectifier

This type is often used for charging ignition and lighting batteries on automobiles and for other purposes requiring only a small current. Two types are made; one

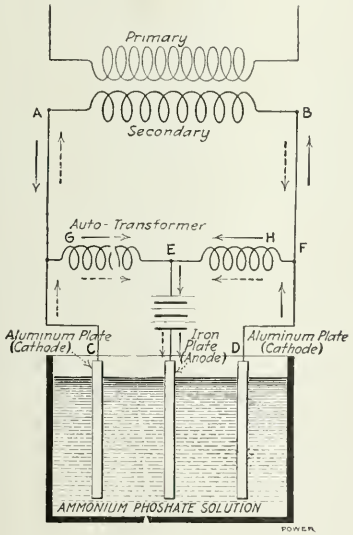


Fig. 2. Aluminum-Valve Rectifier

utilizes but a single wave of each alternating-current cycle while the other utilizes both waves. In the former or single-vibrator type there is a solenoid which acts upon a vibrator or spring. Connections are so made that when the alternating-current wave is in one direction, the spring armature is attracted by the solenoid, and makes contacts such that the current of a high portion of the wave is utilized by the battery. In the next half cycle, however, when the current is reversed, the armature is released, stopping the flow of current in the charging circuit until the next reversal of alternating

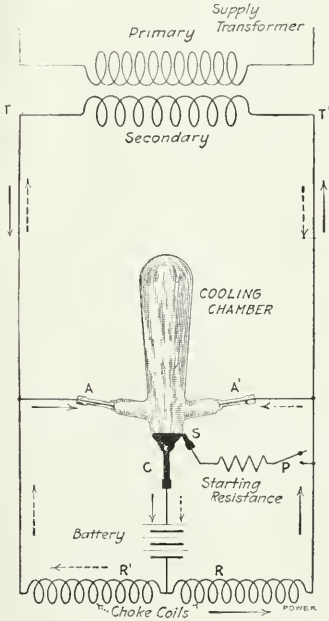


Fig. 3. Mercury-Vapor Arc Rectifier

current when the wave takes the same direction as at first.

In the double-vibrator type, two solenoids are used with either a separate vibrator for each solenoid or one vibrator in common for both. Connections are so made with the solenoids and vibrator-controlled contacts that both halves of the alternating-current cycle are utilized.

The vibratory rectifiers are low in capacity and can therefore be readily connected by lamp cord and plug to an incandescent-lamp socket. Their small size and light weight renders them easily portable, thus affording a ready means of charging the battery when only an alternating-current supply source is available.

The Mercury-Vapor Arc Rectifier

This is the type of rectifier most commonly used in cases where the rotary converter or motor generator is not employed. It consists primarily of a glass bulb from which the air has been exhausted and which contains two anodes usually of graphite and a cathode of mercury.

The operation depends upon a check-valve tendency of the mercury cathode whereby current can flow through it in but one direction, namely, from the anodes. This is due to a high resistance which develops at the surface of the cathode pool at the slightest interruption of the current. Therefore, if a current passing through the cathode from an anode were to drop to zero and tend to change its direction, as in an alternating-current cycle, it would at once encounter the cathode resistance and be stopped.

The current is enabled to pass through the bulb, when maintained in the proper direction, by means of mercury vapor which, during operation, completely fills the bulb.

The connections for a rectifier of this type are shown in Fig. 3; A and A' are the graphite anodes, C the mercury cathode, and S a starting anode at which is also a pool of mercury, but in a smaller quantity than at the cathode.

In starting, the single-pole switch P is closed and the bulb tilted until the two mercury pools come together. The bulb is then rocked backward so that the mercury pools fall apart, drawing an arc as they recede. This breaks down the resistance existing at the surface of the cathode pool while cold, and thereby causes mercury vapor to form. The latter fills the bulb and comes into contact with the anodes, thereby causing the rectifying action of the bulb to start. The single-pole switch P is now opened. The current required for starting is small and is regulated by the resistance shown in series with the starting anode.

At a moment when the terminal T of the supply transformer is positive, the direction of current flow will be as shown by the solid arrows. It enters the tube by anode A, leaves by cathode C, passes to the load and thence to the choke coil R whence it flows back to the transformer. At the next instant, when the reversal in alternating current takes place, A' will become the active anode. However, as an alternating current passes through zero in changing its direction to accord with the second half of the cycle, the arc between either anode and cathode must have an auxiliary force to sustain it until the pressure in the second half cycle has risen to a value sufficient to establish an arc from the other anode. If the arc were not thus sustained, it would cease and thereby stop the action of the bulb. Two choke coils are used for this purpose, one for each anode. When the current flow is changing from anode A to A' the arc hitherto existing between A and C is maintained by the self-inductive action of the choke coil R which upholds the arc until the current flow is established from the anode A'. The direction of current is now as shown by the dotted arrows. Leaving the terminal T'' the current flows through the rectifier by way of anode A' and cathode C, thence passing through the load and choke coil R' to the transformer terminal T. The arc is sustained at the next reversal by the choke coil R'.

The mercury-vapor arc rectifier is commonly used on single-phase circuits. The voltage drop in the rectifier ranges from 14 to 25 volts, depending upon the purpose for which the rectifier is used. The current limit for which glass bulbs can be made is about 50 amp.

The life of the bulbs is at least 500 hr. under normal conditions and with careful usage is likely to be much longer. The size and shape of the bulb are dependent upon the voltage to be used and upon the current which it is to carry. If the voltage is to be high, careful precautions should be observed in placing the anodes. They should be so arranged that they cannot be short-circuited by spatterings of mercury which would allow the current to jump across and stop the operation. Short-circuits of this nature are also likely to damage the bulb. The cross-sectional area of the bulb must be larger for heavy currents than for those of lower value in order that the volume of mercury vapor may be sufficient to carry the load. The size of the cooling chamber is also dependent upon the capacity of the rectifier. The greater the quantity of mercury vapor formed, the larger should be the cooling chamber in order to prevent overheating and also to accomplish the condensation with sufficient rapidity.

Standard rectifier outfits are usually designed for an alternating-current frequency of 60 cycles, but they can be adapted to frequencies ranging from 25 to 140 cycles. The power factor of the system is about 90 per cent. under normal conditions. The efficiency ranges from 75 to 80 per cent., depending upon the direct-current voltage carried, the efficiency increasing with the voltage.

Uses of the Mercury-Vapor Arc Rectifier

The most important purpose for which this rectifier is used is battery charging in connection with automobiles, telegraph systems, annunciators, motor boats and other apparatus or systems making use of batteries of small capacity. It can be readily adjusted to any number of cells within standard limits by taps on the transformer. Its next most important field is arc lighting. It is here used to operate constant-current series arc-lighting systems and also to supply direct current for the arc lights used in moving-picture machines. It is used for the latter purpose because of the superiority of the direct-current arc over that supplied by alternating currents, for this class of work. This is because in the alternating-current arc the light is distributed over the whole arc while in the direct-current arc, it is concentrated at one point, namely, the crater on the positive carbon. The concentration of the light source renders the projection of the emanating rays through a lens more satisfactory than with the alternating-current arc. The mercury-vapor arc rectifier is also used for laboratory work, electrolytic processes and other purposes where small direct currents are required.

The comparatively low first cost, ease of operation, fairly high efficiency, and the relatively wide range for adjustment of currents and voltages are some of the more important advantages of this type over other forms. Other points in its favor are the small space which it occupies and its freedom from moving parts which would require constant attention and care.

An English Engineer's Viewpoint—In his inaugural address, Chairman Vernier of the Newcastle Section, Institution of Electrical Engineers, in reviewing the status of electrical development in England, paid a high compliment to the progress made in these lines in this country. His remarks were in part as follows:

"The hindrances to our progress are by no means technical in character, and it is true that the world's achievements in electrical and mechanical engineering are far in advance of any of the possible requirements of this country (England) for many years to come. When we learn, as from the United States, of 30,000-kw. turbo-generators, of which seven are already under construction, the daily operation of high-voltage overhead transmission up to 140,000 volts and covering distances up to 240 miles, of 300,000-hp. central-station developments and the electrification of some hundreds of miles of main-line railway, we need have no fear as to the ability of engineers to keep pace with the world's industrial demands. But, for ourselves, can we ever hope to maintain our position in the electrical engineering world if we are content to allow our electric supply industry to develop along its narrow way; indeed, have we not already lost too much ground? What training ground shall we offer the rising generation of British electrical engineers if we wish to take our part in the electrical development of our Empire overseas and how shall our electrical manufacturers assume the proper place in the markets of the world when handicapped at home by a restricted market, which might easily be increased to many times its present proportions?"

GAS POWER DEPARTMENT

Fuels for Diesel Engines*

The following points relative to oil fuel are taken from report of Alfred Büchi in "Zeitschrift des Vereines Deutscher Ingenieure." They are concerned chiefly with ata in the matter of low-volatile oils and of their propties as determining their suitability for use in Diesel ngines, as well as with the development of the Sulzer ype of that engine into large power units.

Regarding the fitness of fuel for Diesel-engine operaon the principal factors are heat value, viscosity, volatily and percentages of ash, sulphur, water, free carbon, oke, etc. Comparison is made in the accompanying hart of such properties of fuels of low volatility as are ainly taken into account for the operation of Diesel ngines.

Line 1 shows the range of minimum heat values; the heaper fuels especially appearing much lower in that espect than the more expensive gas and paraffin oils, a oint to be kept in mind in considering prices. Gas oil as a heat value per pound of 18,000 or more B.t.u., and al oil from about 15,500 to 16,600; while in a pound f tar from the horizontal type of retort there is an verage of but 14,800 B.t.u. Similar fuels also show fluctuation of heat values; this dropping notably in he presence of a greater water content.

Line 2 gives the specific gravities which increase with he heat value.

Line 3 shows the viscosity as dependent on the temerature and points out for given cases the greater or esser need for warming the fuel prior to introduction nto the engine cylinder. While the viscosity of the first hree fuels differs but little from that of water, the last our are very high, and with them preheating is necesary; this should be extended to between 140 and 175 deg. '. to assure their uninterrupted flow to the fuel pump and he injection valve. From the last column it is evident hat the degree and variability of viscosity of the tar btained from horizontal retorts militates strongly against 's use.

In line 4 are given the approximate temperatures of olidification of the different fuels under consideration. 'hese temperatures are mostly below 32 deg. F.; the tars, owever, due to their high viscosity, begin to form pasty nasses at relatively high temperatures.

Line 5 gives evaporation curves for different temperatures. Oils which contain easily evaporated elements are nore readily ignited in the cylinder. Failing in ease of vaporation it becomes necessary to increase their inflamnability by other means, for instance, through temperature rise, and it then becomes compulsory to introduce eforehand some special oil for ignition, such as the eadily inflammable gas and paraffin oils. Such addition mounts to about 5 to 10 per cent. of the operating fuel, ut continuous operation with tar oil has been accomlished without this addition. The chart shows that coal-tar oil is lacking in constituents vaporizable at low temperature, and a curve (in dotted line) is added to show that its volatile properties vary greatly with its composition. The tars contain more of such elements than do the tar oils, as is also evident from the curves and as borne out by practical investigations of their use in prime movers.

The data from an average elementary analysis as presented in line 6 show the carbon and hydrogen as the mean of a series of analyses; the remaining constituents are grouped. It is characteristic of gas oil and of paraffin oil that their content of hydrogen is relatively high as compared with that of oils and tars yielded by bituminous coals. Hydrogen raises the heat value and fuels rich in that element produce a more powerful cylinder ignition.

The ash content, line 7, is important with liquid fuels only in the case of those recovered from bituminous coals. It can, of course, make itself disturbingly noticeable with Masut, the residue of naphtha distillation. Ash has a harmful effect on the valves and pistons and may also tend to clog the piping.

The sulphur percentage, line 8, is more or less a detriment, especially in the presence of water; sulphuric or sulphurous acid results with consequent engine corrosion.

A small water content in the fuel is not directly injurious, merely lowering the heat value. However, if the amount be greater than 0.5 to 1 per cent.; see line 9, the continuity of ignition may be interrupted. Leaving such fuel standing for some time separates the water, though this can be accomplished more quickly by centrifugal action.

Lines 10 and 11 give, respectively, the contents of free carbon and coke which play an important part in the adapability of the fuel as they can also unfavorably affect the life of the pistons, valves, etc., and the working efficiency of the engine. For the tars from inclined and horizontal retorts these values are almost prohibitively high. When these two components are materially lessened in amount the use of gas tars can be assured, as it is these alone which still present difficulties in that direction.

Concerning the field of usefulness of crude tar from inclined retorts, as furnished by gas works, practical tests have already been made with a four-stroke-cycle Diesel engine of 800 hp. built by Sulzer Brothers in 1908 for the St. Gallen, Switzerland, water-works; a continuous run of eight full days under normal duty having been maintained. In comparison with the use of gas oil there was, however, a greater wear of the exhaust valves. With a two-stroke-cycle engine where the exhaust is through ports in the cylinder walls and controlled by the main piston the condition would not obtain. The test showed that with a greater allowance for depreciation, operation with tar from inclined retorts is practicable and the St. Gallen gas works are enjoying a very considerable saving thereby. This plant serves a city of about 50,000 in-

*Translated by W. F. Monaghan.

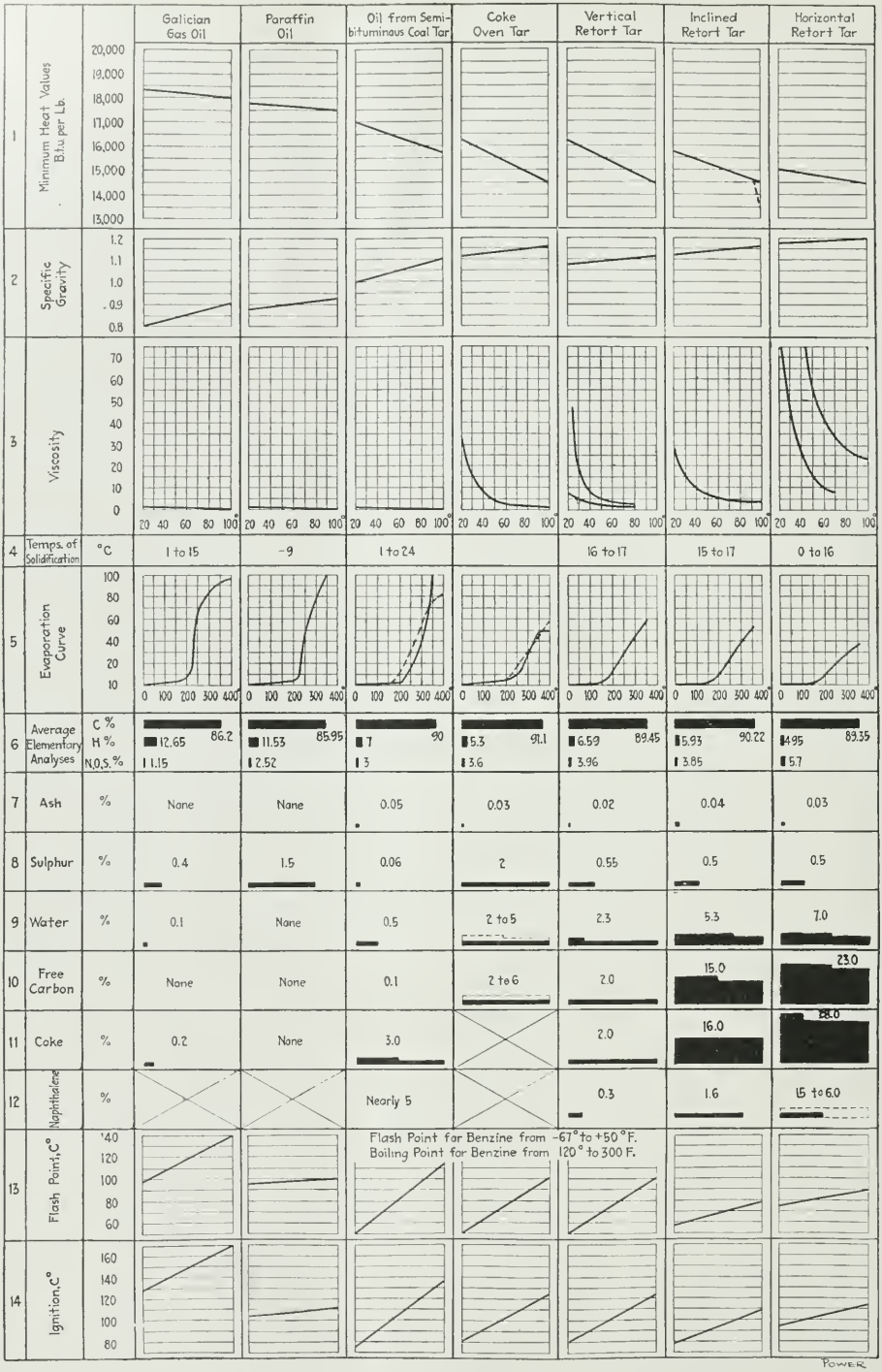


CHART SHOWING COMPARATIVE PROPERTIES OF DIESEL ENGINE FUELS

inhabitants and has a yearly byproduct of tar of about 1500 tons, yielding, at $4.76 a ton, a return of $7140. But with this quantity of tar it would be possible also to generate four million kilowatt-hours, for which, if tar oil were used, about 1320 tons would be required, representing in cost nearly $17,400. Thus through the change from tar oil to tar an annual saving of over $10,200 is effected. If the depreciation charge were increased by, say, $2400, there would still remain a net yearly saving of over $7850; proving that a municipal administration would do well to utilize the tar from its gas works for power production.

The naphthalene content of tar oil and of gas-works tars is given in line 12. At low temperatures naphthalene crystallizes out and hence causes clogging of pipes, etc. In that case, as for the higher viscosities, preheating of such fuel is necessary.

The last two lines give the flash and ignition points, which are of moment in the matter of fire risk. They show that this factor is negligible with fuels used in Diesel engines, and for that reason the installation of such engines and of their fuel tanks is not subject to special legal supervision.

As seen from the foregoing, it is hard to say in advance whether this or that fuel is appropriate for Diesel-engine consumption. A knowledge of the physical and chemical properties does not suffice for all cases; hence a trial run is often requisite before the fitness of a fuel can be determined with certainty.

The Decline of Oil Wells

Technical Paper 51, by L. G. Huntley, just issued by the Bureau of Mines, comments upon the probable causes of the decline of oil wells. It points out that, in general, the yield of a well declines in one or both of two ways: Suddenly, after the initial spurt, due to local relief of pressure, or with relative slowness after the production has become settled.

The initial spurt, which in many cases represents the flowing period of a well's life, is due to a relief of the supersaturated condition of the sand. The sudden release of pressure results in a spurt of petroleum, usually in the form of an emulsion with spray, caused by the expansion of the contained gases, that lasts for a variable time. The duration of this period of high production depends on local conditions such as the porosity and structure of the sand, extent of the pool, rock pressure, etc.

The extent and rapidity of the succeeding decline is governed by several factors which may be classified as follows:

1. Formation of waxy sediments that obstruct the passage of oil from the sand.
2. Decline of gas pressure in the district.
3. Decrease in quantity of oil draining by gravity into the area affected by the well.
4. Decrease in oil supply within drainage area of well due to near-by developments.
5. Flooding by nonencroaching salt water under low pressure.
6. Flooding by salt water under high pressure.
7. Flooding by fresh water from the surface or from an overlying water-bearing formation.
8. Poor management, such as improper casing, unwise rate and time of pumping and failure to clean the well.

The author discusses in detail each of the foregoing causes. Of particular interest, however, is the decline due to the formation of waxy sediment. Petroleum in the so called paraffin-oil fields consists of hydrocarbons of the paraffin series, which range from the heaviest oil to the lightest gas. The gaseous constituents exist in what may be likened to a solution similar to the gas in a bottle of soda water, and as such expand and escape when the pressure is relieved by a well. The sudden expansion and volatilization of these light hydrocarbons has a refrigerating effect, like the expansion of ammonia in an ice machine, thus chilling the remainder of the liquid petroleum and causing the separation of the heaviest paraffin as an amorphous waxy sediment. This clogs the pores of the sand and obstructs the passage of the oil into the well.

Trouble with Magneto

A peculiar and unusual cause of trouble with a magneto recently came under my observation. The machine had been overhauled by a first-class machinist and all the adjustments were mechanically perfect; yet the output was only about 30 per cent. of what it should have been.

The insulation was carefully examined, as also were all the contacts. Tests were made for short-circuits, but the trouble could not be located. Finally, as the field seemed to be very weak, the compound horseshoe magnets were dismounted to see if they were losing their magnetism.

The magnets were found to be all right, but a simple test revealed the fact that one of them had been turned around so that its magnetism opposed that of the other two.

On reassembling the magnets in their correct position, the performance of the machine was entirely satisfactory.

B. Copping.

Kankakee, Ill.

Cleaning Producer Gas

Replying to F. D. Harger's inquiry in the Oct. 28 issue, on cleaning producer gas for purposes of analysis, we have analyzed such gas in the Orsat and the only filter used was cotton packed loosely in a glass tube about 6 in. long and ¾-in. or ⅞-in. bore with a stopper in each end in which was inserted a glass tube for the rubber-tube connections. The gas should be drawn or forced through a few feet of small pipe so it will become cooled.

If I had his problem to solve I would make a cotton filter of a size proportionate to the demand for gas. The cooler the gas enters the filtering material the better it will be filtered.

We have used for the past four years a filter 30 in. in diameter by 4 ft. high for the final cleaning of the gas before it passed into the cylinders of a 125-hp. engine. The filter had three trays on which were packed white waste with a layer of cotton batting on top of the waste in the top tray. I think a properly arranged filter with sawdust for the filtering material ought to give good results.

Anderson, Ind. J. O. Benefiel.

REFRIGERATION DEPARTMENT

Cost of Manufacture in Distilled-Water Ice Plants*

By Peter Neff

In general the manufacturing cost of ice per ton in any plant is the total amount expended during the year in its production divided by the number of tons of ice sold. Ideas as to what items are a legitimate charge will vary somewhat, but to my mind they are: Depreciation, repairs, insurance and taxes, labor, fuel and sundries (oil, waste, ammonia, salt, etc.)

The first three of these items may be termed the fixed charge. They are not dependent on the output, run over the entire year, and may even be greater when the plant is not producing. They are a large factor in the cost of production, and are often partially or totally omitted when thinking of the cost. The last three have a direct relationship to the output, and are the ones usually taken into account.

For the sake of convenience the output for 330 days was taken as a year's production, as all plants should have a period of shutdown for overhauling. Then three periods, varying by 50 days, viz., 280, 230 and 180, were taken as representing productive periods. This division is purely arbitrary, and has been used simply for convenience, but serves to cover the various productive periods as found in ice plants. While the computations herewith are based on ammonia-compression plants, in view of the fact that all the distilled water comes from the boilers they will apply equally well to absorption and to plants where other than ammonia is used for the refrigerant.

TABLE 1. INVESTMENT AND FIXED CHARGE IN DOLLARS FOR STANDARD DISTILLED-WATER ICE PLANTS

Daily Capacity of Plant in Tons	10	15	20	25	30	35	40	50	60	80	100
Buildings	4,000	5,000	6,000	6,700	8,000	9,500	10,500	11,500	12,500	15,500	19,000
Equipment	8,000	11,000	13,000	16,000	18,000	22,000	25,000	29,000	32,000	42,000	56,000
Investment	12,000	16,000	19,000	22,700	26,000	31,500	35,500	40,500	44,500	57,500	75,000
Fixed charges*	1,800	2,400	2,850	3,405	3,900	4,725	5,325	6,075	6,675	8,625	11,250

* Composed of 6 per cent. depreciation, 5 per cent. repairs, 4 per cent. insurance and taxes.

TABLE 2 TONS OF ICE PRODUCED AND FIXED CHARGE PER TON IN DOLLARS

Daily Capacity of Plant in Tons	10	15	20	25	30	35	40	50	60	80	100
Tonnage—180 days	1800	2700	3600	4500	5400	6,300	7,200	9,000	10,800	14,400	18,000
Charge per ton	1 00	0 89	0.79	0 76	0.72	0.75	0.74	0 68	0.62	0.60	0.63
Tonnage—230 days	2300	3450	4600	5750	6900	8,050	9,200	11,500	13,800	18,400	23,000
Charge per ton	0.78	0.70	0.62	0.59	0.57	0.59	0.58	0.53	0.48	0 47	0.49
Tonnage—280 days	2800	4200	5600	7000	8400	9,800	11,200	14,000	16,800	22,400	28,000
Charge per ton	0.64	0.57	0.51	0.49	0.47	0.48	0.48	0.43	0.40	0.39	0 40
Tonnage—330 days	3300	4950	6600	8250	9900	11,550	13,200	16,500	19,800	26,400	33,000
Charge per ton	0.55	0.49	0.43	0.41	0.39	0.41	0.40	0.37	0.34	0.33	0.34

TABLE 3. COST OF LABOR FOR STANDARD DISTILLED-WATER ICE PLANTS

Daily Capacity of Plant in Tons	10	15	20	25	35	40	50	60	80	100
Tankmen	3.50	3.50	4.00	4 00	4.00	4.00	4.00	4 00	4.00	8 00
Engineers	4 50	5 50	5.50	5 50	5.50	6.00	7.50	7.50	7.50	7.50
Firemen	....	....	3 50	4 00	4.00	4.00	4.00	4.00	6.00	8.00
Oilers	....	....	....	....	....	2.00	2.00	2.00	2 00	4.00
Housemen	....	....	....	....	....	....	....	4.00	4.00	4.00
Extra men	....	....	....	....	....	1.50	2 00	2.00	2.00	4.00
Net total	8.00	9 00	13.00	13.50	13.50	17.50	19.50	23.50	25 50	35.50
10 per cent	0.80	0.90	1.30	1 35	1.35	1.75	1 95	2.35	2 55	3 55
Total daily	8.80	9 90	14 30	14.85	14 85	19.25	21.45	25.85	28 05	39 05
Labor per ton	0.88	0 66	0.72	0.60	0.50	0 48	0.43	0.43	0.35	0.39

TABLE 4. MANUFACTURING COST OF ICE PER TON AND AMOUNT OF ICE PRODUCED

Dsily Capacity of Plant in Tons	10	15	20	25	30	35	40	50	60	80	100
180 Days Production											
Fuel	0 66	0 66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66	0.66
Sundries	0.08	0.08	0 08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Labor	0.88	0 66	0 72	0.60	0.50	0.49	0.48	0.43	0.43	0.35	0.39
Fixed charge	1.00	0.89	0.79	0.76	0.72	0.75	0.74	0.68	0.62	0.60	0.63
Total cost per ton	2.62	2 29	2 25	2.10	1 96	1.98	1.96	1.85	1 79	1.69	1.76
Tonnage for period	1800	2700	3600	4500	5400	6300	7200	9000	10,800	14,400	18,000
230 Days Production											
Fuel, sundries, labor	1.62	1 40	1 46	1.34	1.24	1.23	1.22	1.17	1.17	1.09	1.13
Fixed charge	0 78	0 70	0.62	0.59	0.57	0.59	0.58	0.53	0.48	0.47	0.49
Total cost per ton	2 40	2 10	2 08	1.93	1.81	1.82	1 80	1.70	1.65	1.56	1.62
Tonnage for period	2300	3450	4600	5750	6900	8050	9200	11,500	13,800	18,400	23,000
280 Days Production											
Fuel, sundries, labor	1 62	1 40	1 46	1 34	1 24	1 23	1 22	1 17	1 17	1 09	1 13
Fixed charge	0.64	0.57	0 51	0.49	0 47	0.48	0.48	0.43	0.40	0.39	0.40
Total cost per ton	2 26	1 97	1 97	1 83	1.71	1 71	1 70	1 60	1 57	1 48	1.53
Tonnage for period	2800	4200	5600	7000	8400	9800	11,200	14,000	16,800	22,400	28,000
330 Days Production											
Fuel, sundries, labor	1 62	1 40	1 46	1 34	1 24	1 23	1.22	1.17	1 17	1 09	1 13
Fixed charge	0 55	0 49	0.43	0 41	0.39	0.41	0.40	0.37	0.34	0.33	0.34
Total cost per ton	2 17	1 89	1 89	1 75	1 63	1.64	1 62	1.54	1 51	1 42	1.47
Tonnage for period	3300	4950	6600	8250	9900	11,550	13,200	16,500	19,800	26,400	33,000

The value of the land on which the plant is located is not taken into account, but must be considered and added to the figures here given to arrive at the total investment. It is further assumed that there is no charge for water, but that it is pumped by steam power, and th

*Abstract of paper read before the Third International Congress of Refrigeration.

steam is part of that taken from the boilers for distilled water.

Fixed Charges

Table 1 shows the cost of buildings, cost of equipment and the fixed charge. To obtain the cost of the buildings, dimensions as given by two of the manufacturing companies were taken, and the cost based on 8c. per cu.ft. of space inclosed. Nothing has been provided but the necessary equipment, and there will be variations in this item, but not sufficient to seriously affect the results. These two items give what is termed the investment.

Depreciation is that ordinarily adopted, viz., 6 per cent., which will return the cost of the investment in practically 17 years. This has been used both for the buildings and the equipment.

For repairs the 5 per cent. employed has been arrived at from the experience of others in various lines of manufacturing, and form a study of widely scattered ice plants. The 4 per cent. for taxes and insurance seemed to be a fair average.

The three foregoing items constitute what is termed the fixed charge. Table 2 shows how this effects the cost of the ice under the different periods of production, and is obtained by dividing 15 per cent. of the investment by the tonnage for the period indicated, the result being the charge per ton for that period.

Operating Cost

Table 3 shows how the cost of labor was determined, and is self-explanatory. The 10 per cent. added is to cover nonproductive time due to stopping and starting and incidental shutdowns.

The fuel was difficult to decide upon, but here as elsewhere, average conditions are taken. The boiler evaporation was taken at 6 to 1 and the losses between the boilers and the ice cans as 20 per cent. For nonproductive periods 10 per cent. was also added. The price of coal is taken at $3 per ton of 2000 lb. A change of 50c. per ton in the cost of fuel makes 11c. difference in the cost of the ice per ton.

Sundries is also an uncertain item, but the 8c. per ton has been found to check with practical results.

TABLE 5. AMOUNT PER TON TO BE ADDED FOR ICE STORAGE TO MANUFACTURING COST FOR 330-DAY PERIOD

Daily Capacity of Plant in Tons	Tons of Ice Stored												
	1000	1500	2000	2500	3000	3500	4000	5000	6000	7000	8000	9000	10,000
10	0 15												
15	0 10	0.15											
20	0 07	0.11	0 15										
25	0.06	0.09	0 12	0.15									
30	0 05	0 075	0 10	0.125	0.15								
35	0.04+	0.06	0 09	0.11—	0.13	0.15							
40	0.04—	0.05	0.075	0.095	0.11	0.13	0.15						
50	0.03	0.045	0.06	0.075	0.09	0 105	0.12	0 15					
60	0.025	0.04—	0 05+	0.06	0.07	0 09	0.10	0.125	0.15				
80	0.02—	0 03	0 04	0.05	0.055	0.06	0.07	0 09	0.11	0.13	0.15		
100	0.015	0 02	0 03	0.04	0.045	0.05	0.06	0 075	0.09	0 105	0 12	0.135	0.15

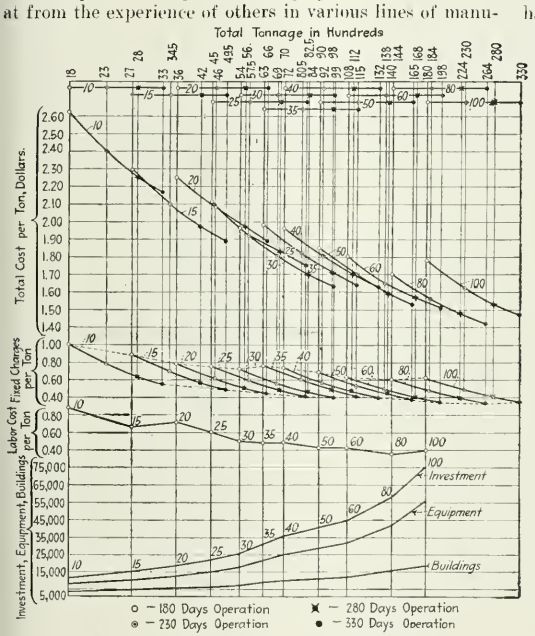
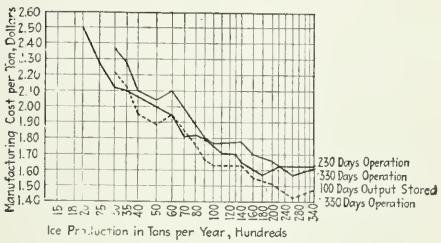


FIG. 1. MANUFACTURING COST PER TON IN STANDARD DISTILLED-WATER ICE PLANTS


Manufacturing Cost per Ton, Dollars
Ice Production in Tons per Year, Hundreds
230 Days Operation
330 Days Operation
100 Days Output Stored
330 Days Operation

TOTAL COST OF ICE PER TON

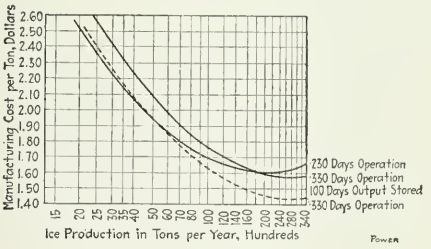


FIG. 3. APPROXIMATE COST OF ICE PER TON DEDUCED FROM FIG. 2.

Total Cost per Ton of Ice

Table 4 shows the cost per ton under the four periods of operation. Turning to the graphic record, Fig. 1, some interesting things are to be noticed. In the matter of fixed charges there is a group from the 20 to the 50 tons that shows a wide variation. This condition is also shown in the grouping of the plant productions as brought

out at the top of the chart, and clearly indicates that there are too many different sizes of plants to cover the range of production. If, now the 25-, 35- and 40-ton plants are eliminated, it is seen that the diagram would be more regular, and that the 20-, 30- and 50-ton plants cover the range even better than the intermediate sizes named. In the labor curve there is a pronounced rise at the 20-ton plant, but this is due more than anything else to the drop from the 10- to the 15-ton plant. If the 15-, 25- and 40-ton plants are omitted, the labor curve from the 20-ton on is decreasing, until the 80-ton is reached, where it is at a minimum, rising again toward the 100-ton plant. The total cost curves show that when all is considered the 80-ton plant is the most economical.

In the standard distilled-water plants under consideration, it is fair to assume that there is sufficient refrigerating capacity to care for an ice-storage house, and that the steam used for this purpose will not increase the boiler load. In the event that the house is located away from the plant, or has an individual refrigerating equipment, it will practically double the cost of storage as here given.

A properly built ice storage will be a substantial affair, and the depreciation will not be as heavy as on a manufacturing plant; 5 per cent. will cover this as well as the repairs. The initial cost may be taken as $5 per ton of storage capacity, and the size will be determined by allowing 50 cu.ft. per ton of ice stored. Where possible the dimensions should be such as to give a maximum content with a minimum of wall surface. For handling the ice, an allowance of 15c. per ton is made and to cover incidentals another 10c. per ton is added. Table 5 has been derived from the foregoing data in this way: The number of tons stored is taken at 50c. per ton, and this amount divided by the total tonnage for a 330-day period, as shown in Table 4, gives the amount that is to be added.

It will be noticed that this has been carried only to the point where the amount to be added in all cases is substantially 15c., which represents a storage period of 100 days' output.

From the cost of production, shown in Table 4, it is evident that anyone operating a plant full capacity for 230 days can, if they have sale for the ice, increase the capacity 43.5 per cent. with practically no change in the cost per ton, by using storage for 100 days' output and operating 330 days.

This statement, however, may be misleading, for this increased tonnage could be got with a larger plant in the 230-day period for less per ton. This is brought out in Figs. 2 and 3. This exemplifies what has already been stated that conditions must be studied and given due consideration in determining what is best in a particular case.

Often there are considerations such as varying demands at particular times of the year that will more than compensate for the extra charge of storing. These figures show, however, that the storage can be used to advantage in increasing the output where the plant is ordinarily shut down part of the time, and that there is not a great deal of difference in cost whether storage is used with the plant operating longer or a larger plant for a shorter period of time. On the other hand, the having of a supply of ice on hand may be the means of largely increasing the revenue and is therefore desirable.

Cost of Power for Ice Making

The writer was interested in attending some of the sessions of the Eastern Ice Association held Nov. 6 to 8 at the Park Avenue Hotel, New York City. Among other papers read was one by C. H. Stevens, of the Brooklyn Edison, in which he made an appeal for business for his company. By looking below the verbiage of the paper, the meaning was that his company would be glad to negotiate with any prospective users of electricity, and would be glad to furnish them current at the highest possible price that his salesman could extract from them.

In discussing the paper, he made the statement that one of the many reasons why the Edison Co. could produce current at a low figure, was because that company bought coal in great quantity. It was purchased at a price which he did not state, though intimated was approximately half what the ordinary user would have to pay. The coal people say that the Edison Co. pay within 5c. per ton of the price at which any purchaser can secure the same coal in the same vicinity. This small reduction would not make a noticeable difference in the cost of power per kilowatt-hour, and for that matter even if they got the coal for nothing the reduction in generating cost should not be more than 0.3c. per kw.-hr.

The question that was in the minds of all the listeners was—"At what price will you sell current?" This question the reader of the paper would not answer.

The practice of the central station is to charge anywhere from ½c. to as high as 15c. per kw.-hr. In almost every other business such as transportation, communication, etc., such discriminating rates have been shown to be illegal. Probably they will be so held in connection with light and power before long in many of the states.

In explanation and partly in excuse for such discriminatory rates, the central-station salesmen say, that owing to the peculiar peak loads that the stations have to meet, they can supply day current at a less rate than current used during the time of heaviest draft on the stations. This, no doubt, is a fact. At the same time it would be just as reasonable for the trolley companies and suburban railroad companies to insist that they should charge more for transportation during the rush period than they do during the nonrush hours.

The central stations have the pleasant habit of subsidizing the large users of current to the detriment of the small users—that is, they will make a contract with the large user of current at a low price, at a loss to themselves, perhaps, for the purpose of preventing the installation of an individual plant, and then make contracts with 50 helpless small users of current at a rate which is five or six times as much, which rate is, of course, exorbitant.

The whole question boils down to at what price can the ice maker buy current? If the central stations will contract to supply satisfactory current at 1c. per kw.-hr. for a term of years, it would be advisable to accept their proposition. If they will not do this it will pay the ice maker to investigate and find out exactly what an isolated plant can do in his individual case. When raw water is not used and it is necessary to distill the water, a boiler will do it, and an engine will not add much to the initial investment.

PAUL BIGELOW.

New York City.

EDITORIALS

Limit of Steam-Turbine Size

Ten years ago when the first five thousand-kilowatt turbine unit was installed at Fisk Street Station in Chicago it was regarded as a giant, not so much in actual size as in its enormous capacity. Engines of great bulk which approached the output of this turbine had been built, but for so compact a unit to deliver five thousand kilowatts and on an overload fifty per cent. more, was then considered remarkable. Since that time advancement in this field has been rapid. It was not long before the capacity of a single unit was doubled. Later the size was increased to fourteen thousand kilowatts, then to twenty thousand and almost simultaneously we hear of turbo-generators designed to deliver twenty-five thousand and thirty thousand kilowatts. The end is not yet, as an order has been placed for a jumbo turbine larger than any other by five thousand kilowatts.

There, of course, must be some limit to the capacity and consequently the physical proportions of a turbine unit, for, as expressed in *Engineering*, all prime movers are in the ultimate subject to the law that while the output increases as the square of the dimensions, the weights involved increase as the cube. For the present this consideration is not so likely to limit the size as the difficulty of transportation, the high cost of heavy castings and forgings, the heavy construction in the building and crane necessary to handle the unit in the plant and the proportions of the foundation. Then, again, there is the question of speed which, as the diameter of the rotor increases, with constructions of equal strength, must be reduced to keep down centrifugal stresses. To furnish three-phase currents at twenty-five cycles calls for a speed of seven hundred and fifty or fifteen hundred revolutions per minute. At the lower speed, which would be used with the larger rotors, it is the opinion of our contemporary that the practical limit of output is about twenty-five thousand kilowatts. Such a unit of the drum type arranged on the double-flow system would weigh from 250 to 300 tons and the heaviest part to be lifted between thirty and forty tons. The size of the forgings required would be about to the limit of what can now be obtained and the cost proportionally more than for castings of smaller size. Then in the larger casings distortions due to their own weight and variations in temperature are more pronounced, necessitating a larger clearance and probably reducing the efficiency.

Except perhaps in very special cases where there is an enormous station output, it would seem that a smaller unit, of say half the capacity, would give better all around satisfaction. It would then be feasible to employ the higher speed, fifteen hundred revolutions per minute, and as a result reduce the size and weight of the unit. The efficiency of a turbine depends largely on the ratio of blade to steam velocity, which, with given steam conditions would vary as the product of the revolutions squared, the square of the mean diameter and the number of rows of blades. It is thus apparent that the volume and therefore the weight of the turbine casing, at fifteen hundred revolutions, is about one-fourth that required at seven hundred and fifty revolutions. The output per ton is greater, the floor space less and the efficiency higher. Incidentally the cost for castings per kilowatt of output would be considerably less and the difficulty of transportation obviated to some extent. Installing or dismantling the unit in the power house would be facilitated and the cost of the generator would be lower.

In the past duplication in the power plant has been considered desirable and in the early days necessary, due to the many breakdowns which were then common. Although not so necessary at the present time, it is still far from safe to put all or even half the eggs in one basket. In stations like Fisk Street or others of mammoth capacity the above reasoning would not apply. Here relative efficiencies and costs will determine the size of unit, but with present facilities and methods it would appear that the advantages from this standpoint also lie with the smaller unit. Of course, too great subdivision increases the total first cost, and the happy medium will be better determined after some of these great units have been in operation for a time and accurate data are available with which to draw a fair comparison.

Safety of Engine Governors

The danger attached to the operation of an engine with a rapidly revolving flywheel is rarely appreciated by the engineer in charge. He usually reasons that if the wheel is sound and furnished by a reputable builder there is no occasion to worry about its safety. Any flywheel can be exploded if rotated at a sufficiently high speed and like the explosion of a boiler from overpressure the stronger the material the worse the explosion.

Evidently the best safeguard against the explosion of a flywheel is careful attention to the devices which control the speed so that it will be kept below the danger point. All boilers used today in civilized communities for generating power have safety valves which are used for the sole purpose of limiting the steam pressures that may be carried. Steam engines are provided with governors to limit the speed and also to perform the function of admitting the proper amount of steam to maintain a uniform speed under varying loads. The purposes of safety valves and of governors therefore are not exactly parallel.

With the Corliss type of valve-gear it is customary to arrange safety cams so that the crab claws cannot move the steam-admission valves when the governor is in the lowest position. To start the engine, a block or equivalent device is provided to hold the governor in a position that will permit the admission of steam during the entire stroke. Blocking the governor in this way is almost the same as blocking the safety valve of a boiler while in the act of raising steam and though this may not interfere with the normal control of the engine while the governor is operative, yet, should any accident happen to the governor or its driving mechanism, a runaway

s quite sure to follow. No engineer can afford to take chances with his own life and reputation, to say nothing of his responsibility for the lives of those surrounding him, by operating an engine whose governor will not automatically move to a position of safety if its parts became deranged.

Governor-blocking devices are to be had that are arranged to automatically assume the safety position upon starting the engine and every engineer should see to it that his engine is properly equipped in this respect. With the purpose clearly in mind it is no extraordinary tax of mechanical ingenuity to devise and apply such a safeguard. A simple form is referred to on page 765. It might be still better if the engineer can persuade his employer to install an independent automatic engine stop and thus operate his engine with a device especially designed for safety as much as a safety valve for a boiler. In some plants using Corliss engines, it is essential that the machinery continue to move when an overload occurs and it is necessary to have the governor blocking in the danger position at all times. In such cases the installation of an independent automatic stop should be demanded by the engineer. It has been the experience of companies insuring against flywheel and boiler explosions that chances of serious accidents are greater from flywheels. In view of such experience no engineer can afford to be careless in regard to safety of the governing mechanism of his engine.

⁂

The Study Course

In this issue begins a new section of the Engineers' Study Course on the subject of Trigonometry which will be immediately followed by one on Elementary Mechanics. While logically these should have followed the division on Mathematics it was felt that it would relieve the monotony to interject an entire change of subject for a season, the better to hold the interest of the students—hence the section on Combustion, Evaporation and kindred boiler-room subjects concluded in the last issue.

Now that there has been this respite it seems appropriate to take up the study of trigonometry and elementary mechanics, and together, as the latter is so directly dependent upon the former. The student is advised to follow the next few lessons closely and to refer back to the earlier course in mathematics should he feel a review of it needful. Particularly to such as may not have followed the mathematics course it is urged that reference be made to it before going very far with the new subjects.

⁂

Vocational Training

How can the man in the operating field better his condition and advance in his vocation? How can he reach that coveted "room at the top"? He knows of its existence just as he knows there is a north and a south pole, but how can he fit himself for the journey?

Probably the plant owner's lack of interest and of cooperation has in great measure prevented the employee's advancement. Most plant owners appear utterly indifferent as to how economy is to be kept up and expense kept down; these little details are left to the engineer. How he does them is his business; but do them he mus or get out.

With a few notable exceptions, chiefly in the manufacturing field, the engineer's vocational training h usually depended upon what he could acquire by his ov laborious efforts after a hard day's work, assisted, nec sarily in a limited way, by his local and national a sociations.

In the power field, a few companies have helped the men to secure vocational training. From the boiler roo have risen men by successive stages to positions of gra responsibility, and their employers have expressed the selves as amply compensated by the rich return in t service and the loyalty now rendered them.

"Power is a factor in all the important affairs of mo ern life," says a writer and thinker, and necessarily t engineer, who makes that power, is also a factor in th the whole purpose is not merely to "make the wheels 'round," but to turn them at a profit. Furthermo electricity, the steam turbine and the waterwheel ha made the engineer's vocation even more difficult, demai ing a degree of operating skill that is wellnigh imp sible to acquire in some cases without special traini

We are told that of all the great nations, ours is t most deficient in vocational development. Germany fo years ago saw its need, and met it; England, Scotla France, Austria, Switzerland, Norway, Sweden and D mark are all paying heed to it. If we would successfu compete in our own chosen field with the large immig tion yearly coming to our shores, we must find the mea to equally educate our own people in their vocations.

⁂

Cleveland Municipal Rates

One of the chief arguments in the fight now being wag in many cities against rate discrimination and in fa of a general revision of central-station rates, is that electrical energy should be sold at less than cost, overhead charges considered. If this is to be applied private corporations, there should be no exception favor of municipally owned plants.

In the new rate schedule adopted by the city of Cle land and printed on page 742, the price per kilowa hour ranges from a maximum of three to a minimum one cent per kilowatt-hour on contracts averaging fi kilowatt-hours or more per month.

When all the factors going to make up the total c (generating, distribution, fixed and overhead charg are considered, even with due allowance for sales in la quantities, it is inconceivable that the figure will co within the minimum rate of one cent per kilowatt-ho Naturally with this attractive rate a number of contra have already been closed and more will be entered i as soon as sufficient capacity is available. If the b of power is disposed of in this way; that is, to a r tively small number of large customers whose dema will entitle them to the minimum rate, it is obvious t the city will lose money and the taxpayers will be c tributing toward the power bills of a few large concer

We realize that it is difficult to fix an equitable r schedule and especially in advance of the completion the plant, when a number of assumptions must nec sarily be made. However, it would be interesting to certain the basis for the rates in question.

READERS WITH SOMETHING TO SAY

Orsat or CO_2 Recorder*

F. D. Harger in his letter of comment under the itle of "Orsat or CO_2 Recorder," in POWER, Sept. 2 ssue, overlooks one important fact. That is, when a uan manages a plant, he should, wherever it is possible nd consistent with efficient operation, keep the cost of roducing power at a minimum. This is to his interest s well as to the interest of his employer. It is not only question of a certain appliance being the means of re- lucing power cost, but rather will not some other ap- aratus, which costs less initially, do as well.

Recording instruments are naturally preferable to hose of the nonrecording type, but in cases where a heaper class of instrument answers the same purpose nd where a continuous record is not necessary, it is a aste of money to purchase them. The tendency now is o analyze flue gases only as long as is necessary to de- ermine the changes required to bring the boiler up to he highest possible efficiency obtainable under local con- itions and then disregard the flue gases entirely e. cept or an occasional checking up. Do with your boiler as ou would with your engine. An indicator is used on an ngine to locate trouble, and after adjustments are made hat ends the use of the indicator for the time. Why hould an expensive instrument be used continuously hen it is unnecessary? I have noticed recorders where sed are checked up with an orsat. Why?

Mr. Harger says he used an orsat to check up with. Vould he have used it had it not been reliable? My riginal letter stated that the orsat was desirable first ecause it furnished as complete and reliable an analysis s was necessary and because of its low first cost and ase with which it could be handled.

A. POHLMAN.

Brooklyn, N. Y.

Jam Nuts†

Mr. Manning's criticism of your note on jam nuts is ardly warranted. He may have had the impression that he inside nut was to be regarded as only finger tight hen the jam nut was set up, overlooking the supposition hat the inside nut had already been set up solid.

In all practical work it is "necessary to obtain both the naximum draft before setting the jam nut and the po- tion of the inside nut without backing it against the utside nut," in which your view is correct, and by your nethod you would not "displace the inside nut by the mount of lost motion," as Mr. Manning states, but only ttempt to. This is what makes the jam nut effective. ll nuts do not have lost motion as Mr. Manning states. ny good lathe hand can make a nut which has no lost notion, and which will never need a jam nut, even in he most severe service. But such a nut must be wrenched on all the way; it cannot be so loose as to be spun on with the fingers. Nuts that can be spun on 8 to 10 turns with one stroke of the hand are the ones that need jam nuts, and the jam nut must be set up good and solid so as to maintain a strain which will not allow the inside nut to be displaced by lost motion. When the inside nut is displaced by any amount of lost motion the jam nut then becomes worthless and may as well be omitted.

L. C. TUCKER.

Newburyport, Mass.

The Polar Planimeter on Circular Charts

Mr. Richardson's courteous comments, published in POWER of Oct. 21, upon my innocent and unobtrusive article which appeared in the Aug. 19 issue, remind me of the man who never uses a railroad train because they sometimes take people where they do not want to go. Rules and railroad trains must be used with judgment, but still used.

I maintain what I said in the original article that the polar planimeter may be used on circular charts to get approximate average values except in "extreme cases" of variation of the recorded quantity. I showed this by actually applying it to a chart in which the average variation was about 20 per cent., and from which the true value was a "little less" than that found by the planimeter. (Mr. Richardson misquotes me as stating that it checked.) I also showed by an example that a maximum variation of 40 per cent. with an average variation of 20 per cent. produced less than 1 per cent. of error. One can surely form an idea from these examples of the limit beyond which the variation may be considered extreme.

Mr. Richardson finds "it evident that the polar planimeter is only of sufficient accuracy when all of the autographic line lies on a narrowly confined portion of the chart." But he forms this conclusion by applying the planimeter to a chart in which the maximum variation is more than 200 per cent. of the average quantity, and the average variation is more than 100 per cent.; that is, he takes an extreme case of variation which in my article was clearly stated to be an exception to the rule. He then seeks to strengthen his conclusion by stating that if the rate (by the chart) had been "zero for the first 12 hr. and 2000 gal. for the next 12 hr., the error of the method would have been 26 per cent." (In his first example it was 7 per cent.) This is absolutely not so, because the diagram for the first 12 hr. would not and could not then be integrated since there would be no record for that time; and the result would be found from the second formula given in my article

$$Mean\ height = \sqrt{\frac{area}{3.14 \times F}}$$

in which F would be 0.5, corresponding to a semicircle. The average rate for 24 hr. would then be one-half that

*"Power," July 29, p. 176; Sept. 2, p. 344; Sept. 16, p. 406; Oct. 14, p. 545; Oct. 28, p. 613.

†"Power," Sept. 9, p. 375; Oct. 7, p. 515.

from the formula, and the error would be less than 7 per cent.

A slight modification of the method I proposed will enable the polar planimeter to give a result within 2 per cent. of error in such an extreme case of variation as that presented by Mr. Richardson. The chart should be divided into a number of time periods in which the variation of the record is not large; the mean height of each of these parts is obtained, using the above formula; and the whole of them averaged with regard to time for the result.

Admitting Mr. Richardson's assertion that there are many recording instruments used in which the record fluctuates widely from hour to hour, it is also true that there are many, if not more, in which the record is very uniform. This is especially the case when such instruments are used for testing, because the significance of test results depends upon uniformity. It follows that the polar planimeter is applicable, not only to rare cases, but numerous ones, with ample precision.

JULIAN C. SMALLWOOD.

Syracuse, N. Y.

Lubricating Engines in Cold Weather

In a manufacturing plant in a northern state there were two large engines in mills, located some distance apart which were so exposed that during cold weather it was almost impossible to get the oil to run through a ⅜-in. pipe to the engine bearings. The oiling system is of the gravity type with a tank located about 15 ft. above the engine. The engines were about 900 hp. each, and as there was much dust in the air a copious supply of oil was required to lubricate them. Sometimes the oil would congeal and stop running, and before it could be started again a bearing would start to heat. Each cylinder was supplied with a 1-qt. sight-feed oil pump, one of which was of such construction that a U-shaped piece of pipe was placed inside of it with the threaded ends extending through the top. One of the ends was connected to a ¼-in. steam line, and the other to a drip line. This kept the cylinder oil warm so that the pump would work in any kind of weather. The other lubricator had a glass body, and was of such construction that it was not possible to put a heating coil inside of it. But a coil was made by winding a length of ¼-in. pipe around a block of wood having a diameter of 2 in. larger than the diameter of the oil pump. There were about five full turns in the coil which was connected to the steam line, and also to a drip line. As this lubricator was more exposed than the other one, a box was made that would just slip over it and the coil to prevent radiation of the heat. That settled the cylinder-oil trouble, but then came the trouble with the engine oil. Each engine had an oil filter in which there was a steam coil in the bottom. Then a coil of ½-in. pipe was made and placed in the overhead tank to keep the oil supply in a fluid state, but in passing through the long, small pipe to the engine it would get thick, and, to prevent this a ⅜-in. steam pipe was laid alongside of and fastened to the oil pipe and covered with a 1-in. sectional pipe covering. This kept the oil warm as far as the oil cups, which were all taken off except those on the crank pins, these being taken apart and the body discarded, the pipe being connected directly to the bottom part containing the sight-feed. A ¼-in. valve was put in each line just above the sight-feed. On th crankpin the centrifugal oiler with its cup and stand wa retained, the oil pipe being tapped into the top cove and a steam coil made to fit around the cup. The reaso for this was to give a small reserve supply in case the oi in the pipes got too thick to run. Sometimes cylinde oil had to be used to keep the pin cool, which was don by shutting off the engine oil and putting cylinder oi in the cup. A steam and oil line was also run to th outboard bearing. Drip valves were placed on the end of all branch steam lines, and a steam valve at the con nection with the steam pipe. Both engines were pipe up in about the same manner, each engine had an en gineer who stopped and started, and did his own oilin when he had time, but before the system was change it took two or three helpers to keep the oil warm.

After passing over the bearings the oil was collecte in a tank below the engine-room floor and pumped b hand to the filter. After passing through the filter was pumped into the overhead storage tank and used ove again. There were two gallons of new oil put into th system every day, and as much was drawn out for lubr cating machinery. The oil filter was cleaned monthly.

This system could have been connected to the exhaus pipe, and the oil heated by waste steam.

Hyattsville, Md. J. C. HAWKINS.

[Lubricating troubles of this kind are not uncommo in the North. When the weather is warm is the tim to take steps to rearrange the system so that there wi be no trouble and fussing about oil lines.

It is altogether too common practice to locate a grav ity oil tank and filters on the engine-room wall or i some other place that is warm in summer but so cold i winter that the oil congeals so before reaching the en gines that the supply at the bearings becomes inadequat

Pumps or air tanks for elevating the oil are used wit most gravity-oiling systems. It should, therefore, b possible in nearly every Northern plant to locate th gravity tanks over the boilers where it is usually quit warm. By putting the oil filters, receivers and pump in an exhaust-steam heated room beneath the engine room floor, the entire system could be kept warm. some of the piping between the gravity tank and th engines is exposed to drafts, as is sometimes the case, b sides covering the pipe, a small bypass line might be le around into the receivers. This would create a sufficien circulation of the oil to keep the system warm.—EDITOR.

Excess Air and CO_2

Why are we continually afflicted and pestered with th CO_2 argument? We have been getting it heavily fo some six or eight years. There is unceasing considera tion of the evil effects of excess air, genuine calamit howling about it, varying with many admonitions tha if the CO_2 is to be made right the necessity exists fo admitting less or more air, etc. Why do we speak of ex cess air at all, why not substitute deficiency of coal? the CO_2 is thought undesirably low and the draft is fixe let the fireman shovel coal on more rapidly and the ra of steaming will increase as will also the CO_2. If, as i a small plant, one or two men are doing the firing and a increase in the rate of shoveling and thereby the rate steaming is inadmissible with increase of CO_2 as its pu

ose, then obviously the draft cannot be considered fixed nce every boiler has a damper and the occasion for ing it is unmistakeably at hand. Restriction of it will duce the flow of air and if the fireman keeps on with e same rate of shoveling as before the rate of steaming ill be unchanged and the CO_2 will be raised. To con- ct the rate of steaming fundamentally with the rate shoveling is correct. There is a minor effect of chang- g efficiency which may follow from change in the CO_2 ntent, but the effect is minor. In general, the rate steaming follows the rate of shoveling, the talk about ntrolling the air supply being based on unmindfulness at the coal supply is basic and is in the hands of the an with the shovel, and, furthermore, that with damp- s or blowers working with any given adjustment the te of coal supply influences enormously the resistance the bed of fuel to the flow of air through it, and ac- rdingly the CO_2 content of the furnace gases.

H. L. H. Smith.

Brooklyn, N. Y.

Fastening Loose Babbitt in Bearing

While the methods of fastening loose babbitt to a aring as told by Mr. Kopple and Mr. Hawkins in the ept. 23 and Oct. 28 issues respectively are interesting, think the following one is better because there is no nger of cutting the shaft with a broken holder screw: By drilling 5/8-in. holes about 1/2 in. deep in the bear- g cap or shell, and then enlarging the hole at the bot- m, the babbitt will run into the holes and hold tight.

H. E. Smith.

Harrisburg, Penn.

[Drills for enlarging the bottom of a blind hole are vailable in the market.—Editor.]

Correction of Diagram

The indicator diagrams, Fig. 1, were obtained from e high-pressure cylinder of a 36x60x60-in. compound, orliss, rolling-mill engine. The trouble with the head- d diagram was that the steam valve opened too early, at is, the head end had too much lead. On the re- rn stroke the steam valve began to open slowly at about , but the piston coming back with the steam valve open ly a very little the steam was compressed to some pres-

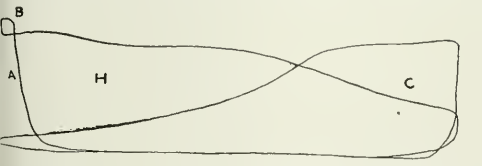


Fig. 1. Diagrams Taken before Setting Valves

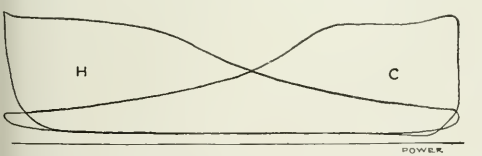


Fig. 2. Diagrams Taken after Setting Valves

sure B, higher than boiler pressure before the steam began to flow back into the boiler. When pressure B was reached, the piston still coming back, instead of raising the pressure higher, sent the steam back to the boiler at practically constant pressure, which is indicated by the line BG. At G the end of the stroke, the piston coming to rest, the pressure dropped to boiler pressure and steam was admitted at this pressure until cutoff.

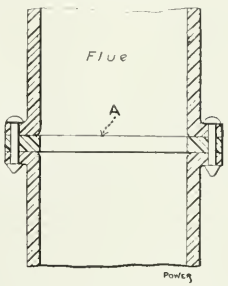
After taking off lead by lengthening the steam rod two turns, and adjusting the cutoff so as to divide the work equally, the diagrams shown in Fig. 2 were obtained.

J. F. Mowat.

Joliet, Ill.

The Adamson Ring

In the Massachusetts state law book on boilers, page 34, it tells of the "Adamson Ring" staying a furnace. Most engineers and fireman do not know about this ring or its use or where it is found.



Adamson Pipe-Joint Ring in Section

The Adamson ring is used on internally fired furnaces for staying of the flues; owing to the possibility of the flue collapsing, something must be used to stay it. The most common way to stay it is by means of a corrugated flue, the corrugations of which act as girder stays.

When the Adamson ring is used the flues are made in short lengths flanged at both ends. Between these flanges is placed a heavy piece of metal, shown at A, then the flanges are brought together, forming the Adamson ring.

This ring is not as reliable as the corrugated flue, owing to the possibility of leaking joints and failure of the rivets.

L. N. Webster.

Springfield, Mass.

Feed-Water Temperatures in Condensing Plants

It is common for operating engineers to desire the maximum feed-water temperature obtainable. The following is to show that in some cases a high average temperature for running hours is a source of loss instead of one of efficiency.

Taking the open type of feed-water heater the maximum temperature is, of course, 212 deg. F. If the load factor of the plant is high, such as during operating hours of pumping plants or flour mills, this high tem-

perature is desirable unless there is a loss of exhaust steam to the atmosphere. But take the plant with the low load factor, such as some lighting and railway plants. These plants usually obtain their exhaust for heating feed water from the auxiliaries. The use of auxiliaries does not decrease in proportion to the decrease in load; in other words, the use of steam by the auxiliary load represents a larger percentage of the total during "off peak" than it does during the "peak." So that if the maximum temperature is reached during the heavy load there must be a vast loss or excess of exhaust steam during the light-load periods. So the proper average for feed-water temperature depends upon load conditions and should be as high as possible with the minimum amount of loss of exhaust steam lost to the atmosphere.

Plants having an average feed-water temperature of 200 deg. F. or over should be watched for exhaust-steam losses, and if possible arrange the auxiliary units with the duplicates electrically driven for use during the light-load period. This serves to increase the operating-load factor as well as eliminating the wasteful steam-driven auxiliary where the exhaust is not needed.

JOHN F. HURST.

Louisville, Ky.

The Effect of Air in Feed Water

We had quite a discussion at our plant recently on the subject of open and closed heaters. There was one point touched upon that was new to me and may be of interest to others. One side claimed that an open heater was the best because it freed the water of air before it entered the boiler. The other side claimed that it was better to have the air pumped into the boiler with the water in the case of a noncondensing plant as the extra air made just that much more steam or working fluid without throwing any more work on the feed pump.

It appears that the air is not only compressed into the closed heater and boiler without any expenditure for power, but it requires no heat to evaporate it as it is already in the form of a gas. And this is not all. As the specific heat of air is about one-sixth that of water, it would require only one-sixth as much heat to raise the air to the working temperature.

Is this another "perpetual-motion" fallacy? If so, it is up to W. H. Booth and others to make the inevitable exposé before I begin selling "air-steam" engine stock.

FRED BOONE.

Davidson, Okla.

Cleaner Sticks in Boiler Tube

After thirteen years of experience with Stirling boilers we ran up against a "stunt" last Sunday that we never had occur before. The boiler, however, was not to blame for what happened.

We have four Stirling boilers, one of which is of 400-hp. capacity containing 88 tubes from the back drum to the mud drum. Last Sunday we undertook to run the rotary cleaner through these back tubes; a wire-wound, 1-in. hose is used with the cleaner and 70-lb. city water pressure applied. The rotary went through the first tube we tried, but in pulling it back, the wire became loosened from the hose and caught between the coupling of the rotary and the side of the tube, about 2 ft. from the bottom. The more we pulled the hose or drove it back the tighter we wedged in the rotary. The question was how to get it out. We could not pull it up and the hose was not stiff enough to push it down.

After trying one thing and another for three or four hours, we went to the blacksmith shop and bent a piece of ¼-in. cold-rolled steel 3½ ft. long so as to form a hook with a turn like a cork screw. The screw was large enough to worm its way up by the cutters and around the legs of the rotary. This gave about 1½ in. of play up and down above the cutters. By forcing the hook down hard at the same time the men in the upper drum pushed down on the hose, we loosened the cleaner and drew it out from the bottom of the tube.

There was not wealth enough in North Adams to induce us to try to draw the rotary up through the tube with that hose so we cut the hose. It is needless to say that before that hose goes back in any tube again it will be thoroughly examined and the wire securely fastened.

JAMES MITCHELL.

North Adams, Mass.

Silencing Noisy Injectors

The articles* by Mr. Davies and others on suppressing vibration in power plants were instructive and interesting. These articles prompt me to inquire if any POWER reader has ever succeeded in silencing noisy injectors. Some of them roar and rattle so much as to unnerve even a boiler maker.

Will the man who has accomplished the silencing of an injector tell us how he did it.

H. D. FISHER.

Newton Highlands, Mass.

Cylinder Welded Successfully

The cylinder of a large engine in a near-by plant was badly broken by a slug of water. The top part of the head-end admission-valve chamber was broken across its entire length. A piece from the head end of the cylinder went with it, and the cylinder head and studs were badly strained and loosened.

There was immediate need for the engine and to wait until a new cylinder arrived would take too much time. It was, therefore, decided to send the parts to a welding company in the vicinity. This firm mended the cylinder by the acetylene process in short order and the engine is now working satisfactorily at the usual pressure of 150 lb.

Last spring I was called to examine an engine that "would not run" as the owner expressed it, and I found the cylinder cracked, due to freezing of water in the cylinder, the drain cocks of which had been left closed. The cylinder, although very badly cracked, was successfully welded in short notice by the acetylene process.

If new parts had been purchased in either of these cases the cost would have been more than double the cost of welding and the loss in time before the arrival of parts would represent a far greater sum.

A. I. HAIGHT.

Kalamazoo, Mich.

*"Power," Aug. 12, 1913, p. 247; Sept. 30, 1913, p. 481; No. 4, 1913, p. 653; Nov. 11, 1913, p. 760.

INQUIRIES OF GENERAL INTEREST

Setting of a Boiler—How much lower should a return-ular boiler be set at the rear end?

A. N. O.

A boiler 16 or 18 ft. long should be set about 2 in. lower the rear end to facilitate drainage toward the blowoff.

Boiler Manhole Reinforcement—What is the advantage of ıcing the reinforcement plate of a manhole inside of the ler?

F. W.

By placing the liner or ring on the inside the shell can calked from the outside and the gasket joint made on a t surface on the reinforcing ring.

Piston for a Rebored Cylinder—When a 14x20-in. engine linder has been rebored, making it ⅛ to ¼ in. larger in ımeter, is it necessary to put in a larger piston as well as ger rings?

J. A. C.

The cylinder should receive a new piston or new adjust-le bearing ring.

Hose Discharge—Will a hose discharge any more water the nozzle is held horizontally than if held vertically, the ssure at the nozzle being the same?

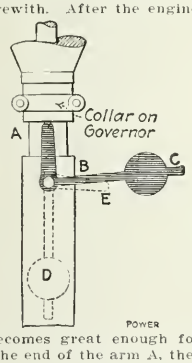
J. W. D.

A hose nozzle held perfectly vertical will not discharge as ıch water in a given time as if the nozzle is inclined a tle to prevent the water falling back on the issuing ream; but a nozzle thus slightly inclined will discharge the ne quantity of water as when held down or in any other sition except vertically upward.

Automatic Governor Release—Is there any arrangement ereby the pin that blocks up the collar of a Corliss engine vernor can be caused to drop out automatically when steam turned on?

A. M.

A simple device used for supporting the collar of a gov-nor in place of a pin, consists of a weighted bell crank, like e illustration herewith. After the engine has been started,



ıen the speed becomes great enough for the collar to be ised away from the end of the arm A, the weight of the arm C throws the bell crank around to the dotted position DE, ıving the governor collar free to fall the same as by re-ving a pin.

Heating Air in Smoke Breeching—Four boilers, only three which are run at a time, are connected to the stack a horizontal breeching 40 ft. long, 3 ft. in diameter at e small end and 5 ft. diameter at the other. Would it be ıssible to put, say a 16-in. pipe through this breeching ngthwise to heat air for drying purposes, the air to be awn through the smaller pipe by an exhaust fan?

A. P.

A 16-in. diameter air pipe would reduce the draft area of e smoke flue about 20 per cent. at the smaller end, and out 7 per cent. at the larger end. If such a proportion of duction in draft area would be permissible, the scheme ght be tried. There would be a further reduction of the rce of the chimney draft resulting from the reduction of its temperature, and the inner or air pipe becoming coated with soot, would require frequent cleaning or else would become very inefficient as an air heater.

Work of Gas Engine—Is the work done in a gas-engine cylinder entirely a consequence of the heat added by the burning of the gas in expanding the mixture, or is it partly due to a change of form of the gas, the new gas occupying more space at a given pressure, or exerting more pressure in a given volume?

H. R. C.

The first supposition is correct; in fact the burned mixture occupies less volume at the same pressure and temperature. This is in accordance with Avogadro's law that equal volumes of all gases under the same conditions of pressure and temperature contain the same number of molecules. For instance, take as a simple case the gases carbon monoxide (CO) and oxygen (O_2) burned to carbon dioxide (CO_2). The reaction is

$$2\ CO + O_2 = 2\ CO_2$$

This means that three molecules have become two and the volume has decreased one-third. The resulting CO_2 occupies the same space as the original CO so that the space occupied by the oxygen has been vacated. The work done in a gas engine is therefore due to expansion of the burned gases due to the heat added by the combustion.

Charging for Heat—One of two tenants in a building operates a power plant and heats with the exhaust steam. The other tenant wishes to purchase heat. How can a proper charge for the service he determined?

F. E. O.

Supplying the additional radiating surfaces will impose increased back pressure on the engine so it is fair to consider the extra steam as costing practically as much as if supplied direct from the boiler. For doing a given amount of heating the cost will be practically the same for supplying steam at one pressure as at another. The amount of steam required would depend on the weather exposure of the rooms to be heated, tightness of the doors and windows for exclusion of drafts, etc., and the temperature to be maintained. Under ordinary circumstances about 10,000 cu.ft. of space would require one horsepower of steam as an average for the season during which heating is required. Its cost taken as additional to the steam required by the engine would be about $3 per hp.-month for heating 10 hr. per working day.

The cubical contents of the premises to be heated; divided by 10,000 and multiplied by $3 will give the cost per month and to this should be added whatever seems appropriate as profit to cover trouble, investment, etc., to finally determine the total charge to be made per month.

Phenomenon of a Draining Vessel—Water flowing from any vessel through a bottom aperture begins a circular motion which increases in velocity as the water is nearly run out and an open space can be seen down through the center which increases in size as the amount of water becomes less. The same effect may be seen around the foot-valve in a pool. What causes this phenomenon?

J. W. D.

Water in flowing from any aperture which presents greater friction on one side than the other, will cause the issuing stream to assume a twist in the same way that the rifling of a gun, or two obstructions in a gun barrel not in line with the barrel, cause the shot to be rotated. In water, the whirling action set up in the discharge aperture is imparted back to the body of water which is presented to the aperture, and this tangential force continuing, increases the circular motion up to a velocity where it is balanced by friction. In an emptying vessel, the constant force being resisted by friction due to less pressure as the vessel empties, the whirling velocity increases, centrifugal force throwing the water out in the form of a funnel. Where the water over the suction into a foot valve is shallow, the centrifugal effect becomes greater than the pressure surrounding the foot-valve, and the effect is assisted by the depression of the water surface due to the discharge through the foot-valve being faster than the water can recover the general level of the surface of the pond.

ENGINEERS' STUDY COURSE

Trigonometry—I

The word *trigonometry* means triangular measure, or better, the measurement of triangles. Originally the object of the study was to solve triangles and that still constitutes the principal purpose of this branch of mathematics, although its scope has been broadened to embrace all investigations of the relations of certain ratios known as the functions of angles.

A triangle is a plain figure having three sides, the junctions of which form three angles. Two triangles are similar if their corresponding angles are equal, and identical if the corresponding sides are equal. If any three of

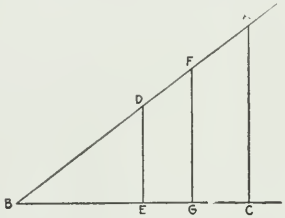


FIG. 1

the six parts—(the three angles and the three sides) of a triangle are known, and at least one of them is a side, the shape and size of the triangle are determined. A little thought will show that one could not construct other than identical triangles and make any one side and two angles alike, or any two sides and one angle alike or the three sides alike. Given, then, the numerical values of any three such parts, the unknown parts can be computed by trigonometry.

From the foregoing it is evident that there is an interdependence of the angles and sides of triangles. To study this interdependence trigonometry makes use of the right triangle.

In Fig. 1, ABC is an acute angle. If a number of parallel lines be drawn perpendicularly to BC, as DE, FG and AC, there will be formed a number of similar triangles, all having the angle ABC in common and the corresponding sides will be proportional. Suppose, for example, that BC has been made just twice as long as BE, it is quite apparent that BA is also twice as long as BD and AC twice as long as DE. Since these ratios hold it is also true that

$$\frac{BE}{BD} = \frac{BG}{BF} = \frac{BC}{BA} \text{ and } \frac{BE}{DE} = \frac{BG}{FG} = \frac{BC}{AC}$$

Suppose numerical values to be substituted for these lengths of sides, then each fraction (or ratio) would have a numerical value that would be the same for all right triangles having the same acute angle.

These ratios, of which there are six, are called *trigonometrical functions* and (with reference to the angle BAO, or angle A for short, Fig. 2) are given names as follows:

The ratio of the opposite side (a) to the hypothen (c) is called the *sine* of A (abbreviated—*sin* A).

The ratio of the adjacent side (b) to the hypothen (c) is called the *cosine* of A (abbreviated—*cos* A).

The ratio of the opposite side (a) to the adajcent s (b) is called the *tangent* of A (abbreviated—*tan* A).

The ratio of the hypothenuse (c) to the adjacent s (b) is called the *secant* of A (abbreviated—*sec* A).

The ratio of the hypothenuse (c) to the opposite s (a) is called the *cosecant* of A (abbreviated—*csc* A).

An easy way to remember these ratios or functions to fix in the mind the picture of this triangle, Fig. and memorize the following in connection with it:

$$Sin\ A = \frac{a}{c} \quad cos\ A = \frac{b}{c}$$

$$Tan\ A = \frac{a}{b} \quad cot\ A = \frac{b}{a}$$

$$Sec\ A = \frac{c}{b} \quad csc\ A = \frac{c}{a}$$

FUNCTIONS REPRESENTED BY LINES

Another and perhaps simpler way of remembering functions is in connection with the diagram, Fig. 3, wh the functions are represented by lines.

All of the ratios given in reference to Fig. 2 can represented by lengths equal to the numerators if denominators are made equal to one. For exam

$sin\ A = \frac{a}{c}$ becomes $sin\ A = a$ if $c = 1$.

Let a circle be drawn with a radius equal to 1 and

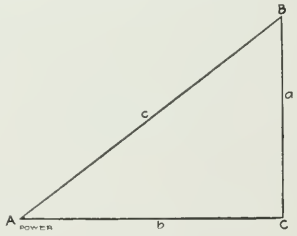


FIG. 2

angle A be laid off at its center, as in Fig. 3, AB (o is now equal to 1 and BC (or a) now represents by length the sine of the angle A; then it may be so mar

Similarly for $cos\ A = \frac{b}{c}$, if $c = 1$ $cos\ A = b$, or line AC in Fig. 3. DB being equal to AC may also taken to represent the cosine.

If, now, the tangent be considered, the triangle n be extended (but is still similar so that the ratios h until the side adjacent to the angle A (b) becomes equal to the radius of the foundation circle of the gram, Fig. 3. Side b is now represented by the line and side a by the line EF which therefore represents its length the tangent of A and may be so marked.

Let the triangle be still further extended until the side opposite the angle A (a) is equal to the radius of the foundation circle as at GH, and then $cot\ A = \frac{b}{a}$ becomes $cot\ A = b$, represented on the diagram by AH, or, what is the same thing, IG, which may be so marked.

For the $sec\ A = \frac{c}{b}$, b has already been made equal to 1 at AF so that the line representing the secant is already in the diagram, being AE and similarly for the $sc\ A = \frac{c}{a}$; when a equals 1, or GH, $c = AG$.

All of the foregoing functions which have been referred to as functions of angles are functions also of the corresponding arcs, since for every angle there is one arc, the arc being measured in degrees as is an angle. There are, in addition, two other functions which appear in the diagram, Fig. 3, but they have no part in the ratios existing in a triangle as indicated in Fig. 2. These other functions are known as the *versed sine* and the *versed cosine* or as they are more often called, the *versine* and the *coversine*. The versine is that part of the diameter intercepted between the extremity of the arc and the foot of

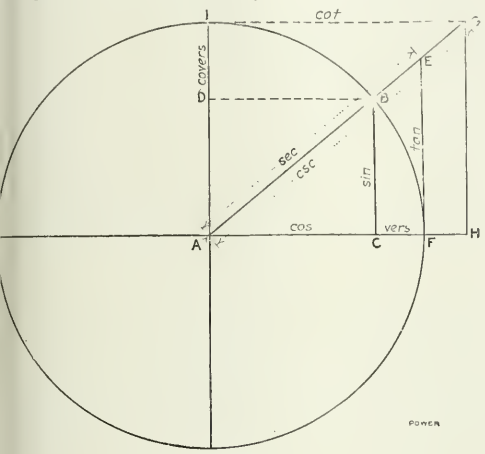


FIG. 3

the sine, shown by the line CF in Fig. 3. As the cosine and the versine added together make the radius

$$vers = 1 - cos$$

The coversine is shown at DI and added to the sine equals the radius so that

$$covers = 1 - sin$$

STUDY QUESTIONS

1. Find the values of the functions of angle A if a, b and c, Fig. 2, equal 3, 4 and 5 respectively.

2. If $a = 24$ and $b = 143$, what would be the $sin\ A$ and what would be the $cos\ B$?

3. The tangent of the angle of elevation of the sun being found to be 0.8 at a certain hour, what is the height of a chimney which at the same hour casts a shadow 160 ft. long?

4. In a right triangle the hypothenuse (c) is 240 in., the $sin\ A = 0.6$ and $cos\ A = 0.8$; find the other two sides.

5. If $sin\ A = cos\ 2A$, what is the angle A?

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"Here's the very note,
And this is what he wrote:"

"Dear Sirs Just a line to let you know to discontinue sending the power book as I dont think its an education book for I know more about engineneering than what the book can learn me so Therefore please stop sending it Obliging Mr Wm Woods Mineville N Y"

"Mr Wm" sure writes us a real polite note, and we are sorry we can't learn him nothing about "engineneering"— But judge, your honor we have other witnesses whose testimony will show that—

⁂

Now, here's a letter we'd cheerfully answer but it has no name or address:

"Dear Editor I would like to have the answer to the fowing No. 1 how ough a return tublur boilder be set. level or 3 inces lower at the back No. 2 how to found out what size punp is needes for a given H. P."

If this unknown seeker after knowledge will watch the "Inquiries of General Interest" page he will find out what he wants to know.

⁂

A St. Louis professor has announced a new law in physics. That's it, we are going clean crazy over the making of new laws. Why not stick to the old-fashioned physics of our boyhood, meaning to be duly respectful toward castor oil and such?

⁂

What chance has a ghost these days? asks "Collier's." An old Back Bay house was thought to be tenanted by "ghouls, ghosts, goblins, wraiths and banshees," until Prof. Schneider, of the Massachusetts Institute of Technology investigated—and then had a man mend a leaking gaspipe. Some psychology!

⁂

"What are the ten greatest inventions of our time?" asked the "Scientific American" recently. It awarded the prize to the contestant sending this list: The electric furnace, the steam turbine, the gasoline automobile, the moving pictures, the aëroplane, wireless telegraphy, the cyanide process, the induction motor, the linotype, the electric welding process. And all this was accomplished in a quarter century. Can you name offhand seven of the inventors?

⁂

The Panama-Pacific Exposition folks have planned a "temple of childhood" to exhibit little kids' pictures. What's its particular value? Of course, friend wife knows her "little Willie is just the prettiest, brightest little tike in all the world," but— Suppose she goes to this exposition and stands next to a big mutt who is saying: "Hey, Liz, pipe de kid wid de putty snoot; he's all mouth but de ears! D'ye git hep to de googoos?" You see, nobody will love Willie but mother. We reckon the temple of childhood is just home. Isn't it?

⁂

A THANKSGIVING PROCLAMATION

Thursday's Thanksgiving Day, Bill! Let's be thankful—thankful that we have a job; that our folks are free of sickness, and of sorrow, and of want; that on occasion we can still scare up a hearty laugh and a cheery smile; that our Ethelbert can lick any other kid on the block; that Edythe and her Adelbert are soon to be made one—and we'll have the "front room" to ourselves. Being thankful is a "thank-you" job, but it pays.

And say, Bill, mebbe our missis, 'way down deep in her heart, is thankful that we are fairly decent fellers as husbands go these days—that's a whole lot to be thankful for, son.

There are mean spots aplenty on the knotty old face of Mother Earth—and perhaps there are folks who think you and me, Bill, are contributing a bit to 'em. Reckon we do feel and act kind of mean and ornery on our off days, we're just plain, run-of-mine chaps at our best. But we're going to do better, and we're trying, ain't we, Bill?

So—let's buck up, you and me, and be thankful!

Effect of Peak Load on Boiler Operation*

SYNOPSIS—The economy of handling peak loads by forcing the boilers to 200 per cent. or more of their rating. Incident to this, greater attention should be paid to the feed water.

The handling of peak loads in power stations supplying service to railway or lighting systems is a matter of daily operation. In addition to the daily load changes there is a peak due to the seasonal changes of traffic or lighting requirements that fixes the maximum demand to which the plant equipment must be proportioned.

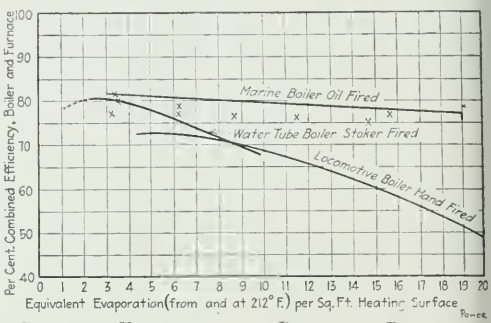
There has long been prejudice against what has been termed the "forcing" of boilers and all kinds of dire consequences have been predicted in addition to exaggerated statements as to the loss in boiler efficiency by such practice. There is, however, a gradual breaking away from these ideas, particularly in the larger and more modern stations.

Approximately one-fifth of the total heat supplied by the furnace, when operating at 200 lb. pressure, is represented in raising the temperature of the feed water from 200 deg. F., to steam temperature. The full opening of the valve may deliver water to the boiler at a rate of five or ten times the normal rate of evaporation. Thus if the feed valve remains open for any considerable time the total heat input from the furnace may be spent in raising the temperature of the water and at this time the output of the boiler is reduced to practically nothing. These features of feed-water regulation are now better understood, with the result that regulators are now available which give a graduated control of the feed water and permit a variation in the water level between any two extremes that may be fixed. The height of the water in the gage-glass, when the water level remains constant, is then some indication of the rate at which the boiler is being worked. This method of feed control enables peak loads of short duration to be carried with a more uniform working of the furnace, as sudden demands for steam will cause a fall in the water level without a corresponding increase in the rate of feed. The value of the graduated control of the feed-water supply will be appreciated when it is remembered that the water contained in the drums of an ordinary 500-hp., water-tube boiler is sufficient to supply full rated capacity for five minutes with a fall in water level of only one inch without other feed supply.

Curves, showing the combined efficiency of boiler and furnace when operating at various rates of evaporation (from and at 212 deg. F.) per sq.ft. of heating surface, are herewith shown. It will be noted that the stoker-fired water-tube boiler is operated to about 10 lb. of water per sq.ft. of heating surface (from and at 212 deg. F.), the oil-fired marine boiler to about 19 lb., and the hand-fired locomotive boiler to slightly over 20.

The usual rating of boilers in stationary service is 10 sq.ft. per b.hp., which is equivalent to the evaporation of 3.45 lb. (from and at 212 deg. F.) per sq.ft. of heating surface per hour. By reference to the curve, it will be noted that the combined boiler and furnace efficiency at rating (3.45 lb. per sq.ft. of heating surface per hour) is 80 per cent.; if the boiler and furnace are worked at double rating the efficiency is 74 per cent. This performance, of course, represents conditions obtaining at a constant rate of working, and in the everyday operation of power stations the combined efficiency rarely exceeds 70 per cent., which is due to the losses that occur during the period of light loads when boilers are banked or held in reserve. By operating at higher rates during peak-load periods the number of boilers that must be banked at the time of light loads will be less and consequently the losses that occur at such times will be reduced.

To show that the total cost of plant output is not increased, but on the contrary is decreased, with the higher rates of the working of the boiler plant, it may be said


Per Cent. Combined Efficiency, Boiler and Furnace
100
90
80
70
60
50
40
Marine Boiler Oil Fired
Water Tube Boiler Stoker Fired
Locomotive Boiler Hand Fired
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
Equivalent Evaporation (from and at 212° F.) per Sq. Ft. Heating Surface
Power

COMBINED EFFICIENCY FOR DIFFERENT RATES OF EVAPORATION

that the boiler-room portion of the ordinary power plant costs about $30 per kw. when boilers are installed on the basis of operation at rated capacity. The cost can be reduced to nearly half this amount if the boilers are installed to operate at double rating during the peak-load periods, thus reducing the first cost of the plant by, say, $12 per kw. The saving in fixed charges on this amount, at 12 per cent. per annum, would, therefore, amount to $1.44 per year on each kilowatt of installed capacity. Taking the yearly load factor at 27.5 per cent., which corresponds to an annual output of about 2500 kw.-hr. per kilowatt of installed capacity, the saving in fixed charges becomes 0.58 mil per kw.-hr. The coal consumption per kilowatt-hour of the plant will be increased in an inverse proportion to the boiler efficiency at the two rates of working and there will be required, if the plant is worked at double rating during peak loads, $^{80}/_{74}$ of the coal at normal rating. Such a plant would operate at 2 lb. of coal per kw.-hr. under normal operation, requiring, therefore, 5000 lb. of coal per year per kilowatt of installed capacity, which at $2.50 per net ton amounts to $6.25 per year. The annual cost for fuel at the higher rate of operation would, therefore, be $^{80}/_{74}$ of $6.50 or $6.75, an increase of 50c. per kilowatt of installed capacity per year for fuel. The net gain at the higher rate of working would, therefore, be nearly $1 per year per kw. of plant capacity. The gain under actual operating conditions would no doubt be greater, because the differ-

*From a report by B. F. Wood, of the Committee on Power Generation, American Electric Railway Engineering Association.

e in the combined efficiency of boiler and furnace, un- the average rate of working, would not be as great the difference at the maximum rate of working as taken ove. It is evident, therefore, that lower total costs may obtained by operating the boilers at higher rates of poration during the peak-load periods.

It is necessary to give greater attention to the condi- n of the boiler-feed water, where the boilers are to be erated at high steaming rates as injury to the tubes more likely to occur under this condition, particularly the water contains scale-making matter. This, of rse, is of less importance where surface condensers are d and the percentage of makeup water is small, but in nts where jet condensers are used it may be necessary provide for treatment of the feed water. The usual thod of treatment is by caustic soda or soda ash, added ile the water is hot, preferably at about 200 deg. F. ter this treatment, and before the water is fed into the ilers, dry soluble tannin extract may be introduced ich will keep the scale-making matter in solution. The st for chemicals for this treatment is from one to two ts per 1000 gal. and gives as good results as can be tained, except by evaporation.

There is a process of water purification by evaporation ing tried out at the present time, where the heat is pplied by compressing the vapor by a positive blower about 1 lb. above atmospheric pressure. It is stated at this system will evaporate about 100 gal. per kw.-hr. d if current for the operation is taken during the off- ak hours it may be furnished at the actual cost of the el.

In plants that are to be worked at high rates of evap- ation it is important to select only those types of boil- s which are free from stresses, due to temperature anges, and which permit of easy renewal of tubes. When ilers are to be worked during peak-load periods at from to 10 lb. of water per sq.ft. of heating surface, that from two to three times the rated capacity, the total st of the boiler plant will be so greatly reduced that e very best boiler structure for the purpose can be se- ted without greatly increasing the cost of the plant. ne cross-drum type of boiler offers advantages for high tes of working as the discharge from the upward cir- lation of steam and water is near the center of the oss drum and therefore near the normal water level, us liberating the steam near the surface of the water ich permits of freer and more rapid circulation. It this type of boiler that is designated as the marine iler on the curve showing the very high performance d high economy.

The Value of the Engineer

By Dwight B. Pangburn

In the following is an example of how the engineer n make himself more valuable—both to his employer d himself.

A certain factory in New England has a power plant ntaining five return-tubular boilers aggregating about 0 boiler hp., supplying a 100-hp. Corliss engine, a 100- n refrigerating machine (compressor), a direct-con- ected, direct-current generating unit of 75 kw. (the ime mover being a horizontal compound engine), a iplex pump of 2,000,000 gal. per 24 hr. capacity, belt driven from a vertical simple engine, and various other smaller steam pumps. The product has to be both heated and cooled in process of manufacture. This requires steam for heating and refrigerating plant for cooling. The engineer has charge of both the operating and repair departments, and is also called on to superintend his men in doing any installation work necessary in the plant.

A little before the end of 1907 the chief engineer left to take a better position and a new engineer was employed. The first thing the new man was told was that the one who had preceded him was a pretty fine engineer, and that if he could keep things running as well as they were when he took the job the company would ask nothing further from him. Whether this was said because the officials believed it or not, it very naturally had the effect of starting the new man to look for every chance he could find to make improvements. He was given his predecessor's last year's record as a model and did not learn for some time that it was 20 per cent. better than the man's average for all the time he had been on the job.

The first thing that caught the new man's eye was that the firemen were not firing well. They were leaving holes in the fires all the time and were sloppy in many ways. He also saw that the firemen were working in two shifts of 12 hr. each. He reasoned that no one could expect consistently good firing from men throwing coal for 12 hr. a day, seven days a week, so he immediately cut the hours from 12 to 9 per day, giving the men one day off in two weeks, and giving them the same amount of pay per week. He also installed a recording pressure gage where the firemen could see it and at the same time requested them to fire a little better—there has not been a hole in the fires since, and the cards from the gage are very good.

There had also been, formerly, two watch engineers, on two 12-hr. shifts and working 365 days a year. Considering that what was fair for the firemen was fair for the engineers, he added another watch engineer and made three 8-hr. shifts, thus also allowing the men two Sundays off out of every three.

Not content with thus assisting the operating force to make a better record, he made another valuable change. The layout of the plant makes it necessary to have the coal dumped in the yard, being wheeled from the coal pile into the boiler room in wheelbarrows by hand. The boiler-room floor was of earth. The firemen frequently dug up sections of the floor and threw it into the furnaces along with the coal. This made it bad for all concerned so the engineer had a smooth concrete floor laid in the boiler room and a walk out to the coal pile, so that the coal could not only be easily wheeled in from the coal pile, but could also be easily shoveled up from the floor.

In addition to these radical changes he began buying coal that cost 50c. more per ton, proving by analyzing it that he was getting more heat units per dollar.

All these changes came in the year of 1908, yet by looking at the appended table it will be seen that the saving was sufficient to more than pay for the increased wages and other expenses, as the operating costs were 1.1c. less per unit of manufacture than in the preceding year, this being about 5 per cent. less cost while 7 per cent. more work was turned out of the shop. During the month when the best showing was made, when 10,100

units of manufacture were turned out, 521 tons of coal were saved, as compared with the corresponding period during the preceding year, when the amount of work done was almost identical.

The new engineer soon found why his predecessor's last year had been the least expensive. It was because he had left all the work he could for the new man to take care of. Among other things there was hardly a tight valve in the whole plant, even on the ammonia lines. A valve-seating machine was purchased and as many men as could be spared were set at work on the piping. In time the valves were all fixed and the leaks in the piping taken care of, often by putting in whole new lines of pipe. This work was hindered by having at this time to devote half the force to the work of installing automatic sprinklers in a large part of the works, the men's pay still being charged against the operating department, while they were doing this work. While in the piping business, and going on the idea that each 6 sq.ft. of exposed steam piping will eat up one ton of coal per year, half a carload of pipe covering was put on, and so the coal pile was again conserved.

After the company was induced to buy the operating department an indicator, something never considered worth while before, the engine valves were shown to be out of adjustment and the rings leaking badly. By fixing these two difficulties the amount of steam used for power was cut down about 20 per cent., which soon paid for the indicator.

Still the new engineer thought that the saving was not enough. He was having the boilers cleaned regularly, and oftener than ever before but he thought they needed further attention. He secured a $25 flue-gas apparatus and tested his flue gas. To his surprise he found only 3.5 to 4 per cent. of CO_2, showing that two or three times as much air was being supplied as should be. He had already plugged and cemented up numerous holes in the boiler settings, and decided the trouble must be in the hollow walls between adjacent boilers. (The boilers were in one battery of three and one of two.) These walls seemed in good condition, but he investigated more carefully, rebuilt the walls entirely and the flue gas showed 10 to 12 per cent. of CO_2 while the draft was also much improved. This fault might not have been discovered for a long time without the flue-gas tester, and thus a $25 instrument and a little care saved a lot of money.

As before stated, steam is used in one part of the works in the heating coils in boiling retorts. The boiling is accomplished at a vacuum of 15 in. or more, maintained by a barometric condenser. Live steam from the boilers was being used for the boiling, coming at 60 lb. gage pressure to a valve at the side of the retort where the quantity and consequently the pressure, were controlled. After pointing out that steam at 60 lb. had only a temperature of 310 deg. F. while at 4 lb. it had 225 deg. F., and that the total heat available in a pound of steam at the two pressures did not differ by more than 25 or 30 heat units, he obtained permission from the superintendent to try using exhaust steam instead of live steam. The superintendent feared it would cut down his production, but since exhaust steam was first run through the heating coils, no live steam has entered them, not even in winter.

The engineer had discovered that the back pressure on the engines was about 5 lb., because the main exhau was too small and had nearly a dozen right-angle turn in it. Now the exhaust steam is run direct to the boilin retorts and from them through a large feed-water heate to a barometric condenser. As a result the engines e haust against from 3 to 4 lb. back pressure, or less, th exhaust passes through the boiling coils and then hea the boiler feed and goes on to the condenser. The wate used in the condenser to condense the steam comes dow through the feed-water heater and then through a hom made economizer made of pipes running through the u take of the boilers, and so is finally pumped into th boilers, usually at a temperature of 180 to 200 deg. While the retort coils had to be bypassed and a ne and larger feed-water heater put in, the saving soon pai for the expense.

Naturally all these changes did not occur at once. Th chief has only a few men to work for him and the oper tions described take time. The work mentioned was mo of it done, however, during 1908-9-10. More improv ments are going on, and all could have been done in le time were it not that the officers of the company wer in the beginning, somewhat slow to give the engineer a fr hand, and he had to fight for whatever he got. Now th have got to where they swear by the engineer instead of him, and it shows nicely on his pay check, too.

The appended table shows at a glance the results of th engineer's crusade against incompetency, carelessnes and the overloading of labor. 1907 shows the last ye of the first engineer. It is 20 per cent. better than h average. The tables are based on the unit of manufactur which has remained the same.

The first line shows the number of units of manufa ture turned out during each year.

The second line, giving coal in tons per unit, sho how the boiler-room economy is helped by buying goo coal and firing it well. The third line, giving coal p unit in dollars, shows the financial result of such actio the cost of coal ranging from 17.8 to 22.3 per cent. le than in 1907.

The fourth line gives operating cost per unit in do lars. This includes the cost of coal, labor and supplie It is higher for 1909 and 1910 than in 1907, but th result of better quality labor is shown in the reduced r pair bills.

Line five shows that the repairs per unit have grow steadily smaller, due to the better labor and better a rangement of the plant.

In the seventh line is shown the percentage of im provement, figured on 1907 as a basis. While the grea est improvement financially is 19.1 per cent. (in 1911 the service which the whole factory gets from the e gineering department is admitted to be 50 to 100 p cent. more satisfactory. This is because the men i the department, being contented, pull together inste of apart.

The sixth line gives the total cost per unit of the eng neering department, this being the sum of the operatin and repair charges. It may be summed up by sayin that where the old engineer turned out one unit with di satisfied, inefficient, underpaid and overworked labor, ar a plant that was falling to pieces, for 49.3c.; the ne man, after three years of constructive effort, was turnin out the same unit with higher-paid, satisfied, efficient e gineers, firemen, etc., and with a plant that is in fi

dition and worth much more than when he began, all 39.9c., or 80 per cent. as much as formerly—and he still doing it.

This is an actual instance of engineering efficiency in ich the saving in money amounted to thousands of lars while the human saving was also enormous. What means to workmen is this: Earn more for your em-yer and you will earn more for yourselves. What it ans to employers is; hire good men and pay them ough to keep them satisfied. Both will profit as a re-t of such action.

TABLE

Year	1907	1908	1909	1910	1911
s manufactured	130,581	139,593	109,612	100,200	127,201
per unit, tons	0.386	0.299	0.349	0.342	0.314
per unit, dollars	0.130	0.101	0.107	0.106	0.103
ating cost per unit, includ-g coal, dollars	0.207	0.196	0.218	0.216	0.196
airs per unit, dollars	0.286	0.267	0.265	0.219	0.203
Total, engineering dept., dollars	0.493	0.463	0.483	0.435	0.399
entage of improvement	0	6.08	2.03	11.76	19.07

Lytton Vacuum and Lifting Trap

This trap has been designed to automatically remove ndensation from any apparatus under low steam pres-e or any vacuum obtainable, and lifting the water to desired point. With a 12-in. head the trap will work to its normal capacity, which is increased with more d.

The trap is simple in construction, consisting of a indrical body held in place between two heads, by ough bolts. The bottom head contains a tee which

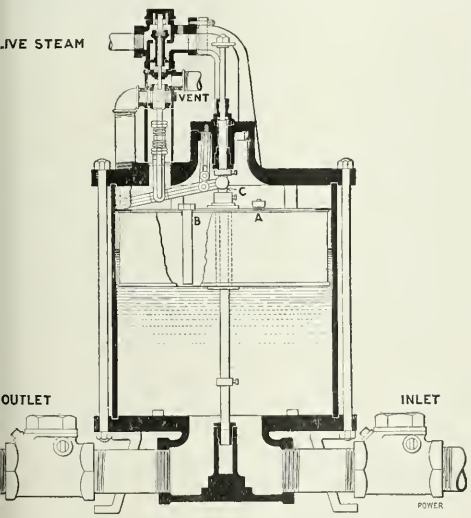


Fig. 1. Section through Vacuum Trap

ves as an inlet and discharge, the connecting pipes be-g fitted with horizontal swing check valves.

On the inside of the trap there is a floating piston ich operates a regular return steam-trap valve, placed the outside of the trap. The top of the floating piston provided with a steam-inlet valve *A*, Fig. 1, and a vac-m valve *B*. A tappet spindle *C* passes through a hollow ter of the floating piston. As the trap fills with water e piston rises until the tappet is reached when any further lifting of the piston raises the lever which is attached to the valve stem of the steam and vent valves. This movement opens the steam valve and admits steam to the body of the trap, forcing the water out through the outlet pipe. At the same time steam is admitted to the interior of the floating piston through the valve *A*,

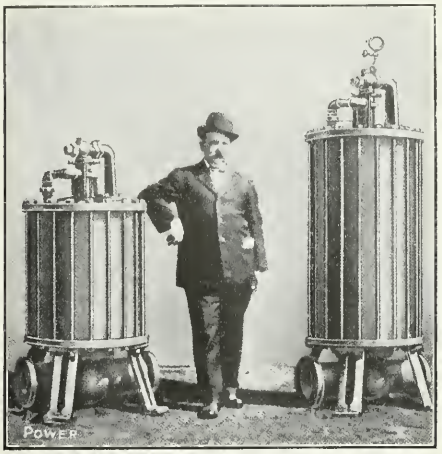


Fig. 2. Two 6-in. Vacuum Traps

which equalizes the pressure on the inside and outside of the piston.

When the trap has emptied, the floating piston drops until the lower tappet is reached when the tappet rod is forced downward, which movement closes the steam-inlet valve and opens the vent, thus admitting atmospheric pressure to the trap. The valve *B* permits of breaking any vacuum that might have formed within the floating piston from condensation of the steam admitted through the valve *A*.

There are several salient points of interest in the design of the trap, which is manufactured by the Lytton Manufacturing Corporation, sales office, 50 Church St., New York City. It requires but very little floor space, as illustrated by Fig. 2. The trap shown at the right is a photograph of the largest trap in the world. It has a capacity of 1000 lb. of water per minute at its normal rate of discharge and 1500 lb. with a maximum discharge. The small trap is of standard size with a capacity of 400 lb. of water per min.; maximum discharge 600 lb. per min. Both traps are 30 in. in diameter. The large one is 80 in. high, the small one is 54 in. high. Both have 6-in. inlet and outlet connections.

The trap will handle liquids at any temperature from 40 deg. up and can be used in connection with a dry-vacuum pump to drain surface condensers. As it does not churn the water, it is valuable in ice plants, as clean condensation will be had even if a small quantity of pure oil is handled with the water.

Cooling Generating Windings—To aid in cooling generators on overload, Sydney F. Walker, in the "Electrical Review and Western Electrician," for Nov. 15, proposes to refrigerate the air and thus obtain a greater temperature range in its passage through the generator windings. His plan is to use the wet-filter process of cleaning and cooling the air, but instead of a water spray, to substitute brine from a refrigerating system.

Purchasing Agents Form Association

The formation of the National Association of Purchasing Agents was consummated at the Hotel McAlpin, Thursday evening, Oct. 16. Headquarters will be in New York City. Over 100 purchasing agents and buyers, representing large industrial corporations, railroads, steamship lines, street railways, gas and electric companies in New York, New Jersey and Connecticut are now members, and many others intend joining toward the end of November.

H. T. Leeming, of Thomas A. Edison, Inc., was elected temporary chairman, and Elwood B. Hendricks, the organizer, was elected temporary secretary and treasurer. Mr. Hendricks is well known to purchasing agents, having been connected with "Hendricks Commercial Register" for a number of years, and is a son of S. E. Hendricks, president of the Hendricks-Sullivan Corporation. Temporary headquarters are at the Hotel McAlpin, 34th St. and Broadway.

This association will be devoted entirely to the interest of purchasing agents and buyers, and will have subassociations in all sections of the country. Some of the objects are forming the purchasing agents and buyers into a national body; the standardization of purchasing routine and methods; investigating new appliances and materials; improving methods for diffusing market information; gathering and disseminating data on buying; standardizing specifications, and other features of benefit to the agent or buyer.

The active campaign will be inaugurated after the next meeting in all the principal commercial centers for the securing of new members. Purchasing agents and buyers are invited to communicate with E. B. Hendricks, P. O. Box 1406, New York City.

Modern Science Club's Activities

The winter's activities of educational and social work at the Modern Science Club of Brooklyn are now in full swing. The educational committee will hold one lecture each month, on the third Tuesday evening. It was thought that in this way those who wished to attend these lectures would have a better opportunity of being present, as many of the members are interested in other engineering associations; it also insures a much larger attendance and more interest.

For Tuesday evening, Nov. 18, the lecture will be on the preservation and manufacture of metals for boilers, by W. P. Wilkinson, supervising engineer of the Perolin Co. On Dec. 16, W. W. Montabro, of the Harrison Safety Boiler Works, will talk on the hot-water meter. The clubhouse is conveniently located at 125 South Elliott Place, Brooklyn, about two minutes' walk from the terminus of the subway, at Atlantic Ave.

Engineers and others interested in steam engineering in Greater New York are always welcome at the clubhouse, which is admirably fitted up and adapted for the purposes of an engineers' club. It contains parlors, two large meeting rooms, billiard room and cafe, and is now the headquarters of several operating engineers' organizations in Greater New York, including N. A. S. E. organizations and the United Craftsmen's Council of Engineers. It is also the headquarters of the Brooklyn branch of the Ladies' Auxiliary of the N. A. S. E.

On each Tuesday evening a general social meeting with entertainment is held, except on the third Tuesday of each month, when a special lecture program is provided.

The officers of the club are: President, John P. Bonney, of the Thompson, Bonney Co., electrical manufacturer and contractor; vice-president, James R. Coe, president, National Association of Stationary Engineers; secretary, John P. Martin, chief engineer, College of the City of New York; financial secretary, James W. Starrett, chief engineer, Manhattan Brass Works, New York; treasurer, George O. Kaley, chief engineer, Naval Y. M. C. A., Brooklyn, N. Y. The directors of the club include many men who are interested in steam-engineering work.

The club is in a very prosperous condition and invites all people interested in steam engineering in Greater New York to come to the clubhouse and make it their headquarters. A warm welcome is assured.

Westinghouse Machine Co. Extends Facilities

At a recent meeting of the executive committee of the Westinghouse Machine Co., $125,000 was appropriated to provide additional manufacturing facilities.

This equipment is required to take care of the company's increasing business, owing in a large measure to the new lines of products developed, particularly the impulse turbine the reduction gear, which in addition to the demand for marine installation, is finding wide application in connection with the large direct-current generators. The gear is interposed between the high speed of the turbine and the low speed of the direct-current machine with its commutator.

The company contemplates devoting a portion of the appropriation to securing additional machine tools designed to use high-speed tool steel, fully realizing their advantages and thus adding to the already well equipped shop which this company now has in operation.

SOCIETY NOTES

The fourth annual convention of the Practical Refrigeral ing Engineers' Association will be held at Dallas, Texas, o Dec. 11, 12 and 13, at the Hotel Adolphus.

The sixth annual meeting of the National Gas Engine As sociation will be held at Toledo, Ohio, at the Boody Hous on Dec. 4, 5 and 6. An interesting program has been pre pared; some of the papers will appear in abstract in an earl issue.

PERSONALS

M. G. Doll has taken the position of general sales mar ager with the Bury Compressor Co., Erie, Penn.

Leo G. Smith, who has been superintendent of the open hearth works of the Prime Steel Co., Milwaukee, Wis., f the past two years, has been appointed works manager that plant and also of the company's crucible plant.

Heinrich J. Freyn, formerly consulting engineer of th gas-engine department of the Allis-Chalmers Manufacturi Co., Milwaukee, Wis., has recently joined the H. Coppers C Chicago, Ill., in the capacity of third vice-president.

Otto Wartenweiler, formerly in charge of the mechanic design and construction of a 400-ton milling and cyanidi plant for the Commonwealth Mining & Milling Co., has open an office in the Van Nuys Building, Los Angeles, Calif. H will be the manager for Otto Wartenweiler & Co., enginee and contractors.

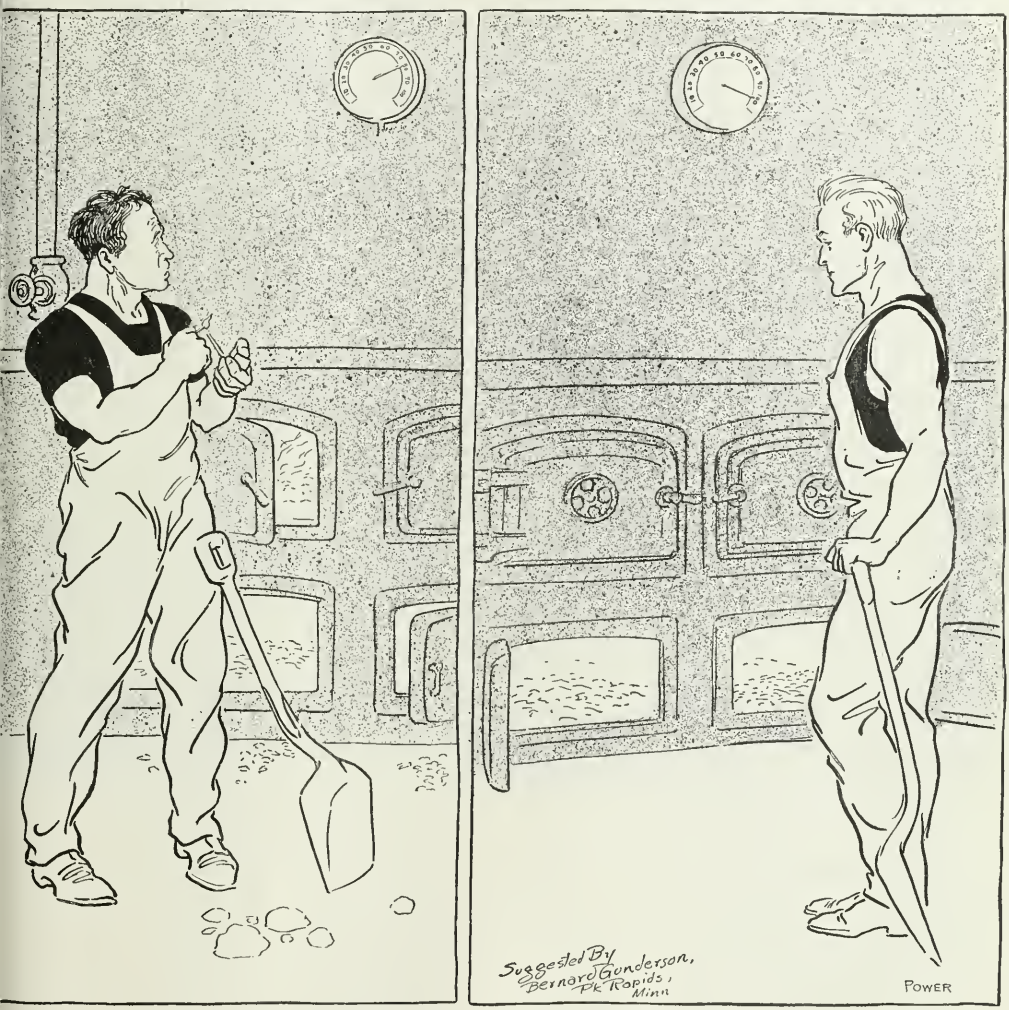
Frank McManamy has been appointed by President Wils to the position of chief inspector of locomotive boilers for t Interstate Commerce Commission to succeed Chief Inspect John F. Ensign, whose death was announced in "Power" Oct. 14. He entered the service of the Interstate Commer Commission six years ago as inspector of safety appliance and while in that position served on the committee whi represented the commission in the preparation of the prese United States Safety Appliance Standards. When the loc motive inspection law was passed he was promoted by Pre dent Taft to the position of assistant chief inspector, whi he has held up to the present time, serving as acting chi during the illness of Mr. Ensign. Mr. McManamy has been member of the Brotherhood of Locomotive Firemen and E gineers for over 20 years.

OBITUARY

A. J. Frith, associate professor of mechanical engine ing at Armour Institute, Chicago, Ill., died suddenly, in office at the institute on Monday morning, Nov. 10, 1913. P fessor Frith, who was 61 years of age, was born in Phi delphia, Penn. He graduated from Rensselaer Polytech Institute, Troy, N. Y. After graduation he taught thern dynamics in Lehigh University, Bethlehem, Penn. Later, was connected with a government project in the Mississi Valley and then with the Diesel Engine Co., in New York. has been associate professor of mechanical engineering Armour Institute for the last five years, previous to t having been connected in various capacities with several gineering companies. While at Armour he pursued so important research work. He was a member of the Ameri Society of Mechanical Engineers, the American Society the Promotion of Engineering Education, and the Assoc tion of Automobile Engineers of America.

POWER

Vol. 38 NEW YORK, DECEMBER 2, 1913 No. 23



TWO KINDS OF FIREMEN

Completion of the Hale's Bar Works

SYNOPSIS.—Water-power plant, designed for total capacity of 43,862 kw., to supply Chattanooga with current at prices ranging from 1½ to ½c. per kw.-hr. Units consisting of three vertical turbines on one shaft and a lock with the highest single lift in the world are interesting features.

As two flag-bedecked steamers backed out into the Tennessee River at Chattanooga on Thursday morning, Nov. 13, the whistles of the factories lining the banks sent up a resounding salute. It was the Godspeed of industrial Chattanooga to those who were going to Hale's Bar to formally signalize the completion of the dam and

Army, suggested years ago, as an alternative to the annual expenditure for keeping the river open, the building of a dam which should regulate its flow and increase its depth. Later C. E. James and J. C. Guild, two progressive citizens of Chattanooga, conceived the idea that the power made available by such a dam would warrant the cost of its construction and in 1904 secured the passage of an act of Congress, authorzing the City of Chattanooga, or others to whom it might delegate the right, to construct such a dam at Scott's Point, the conditions being that an ample lock should be provided for navigation and that the builder should be entitled to the power privileges for a term of 99 years. The city ceded the

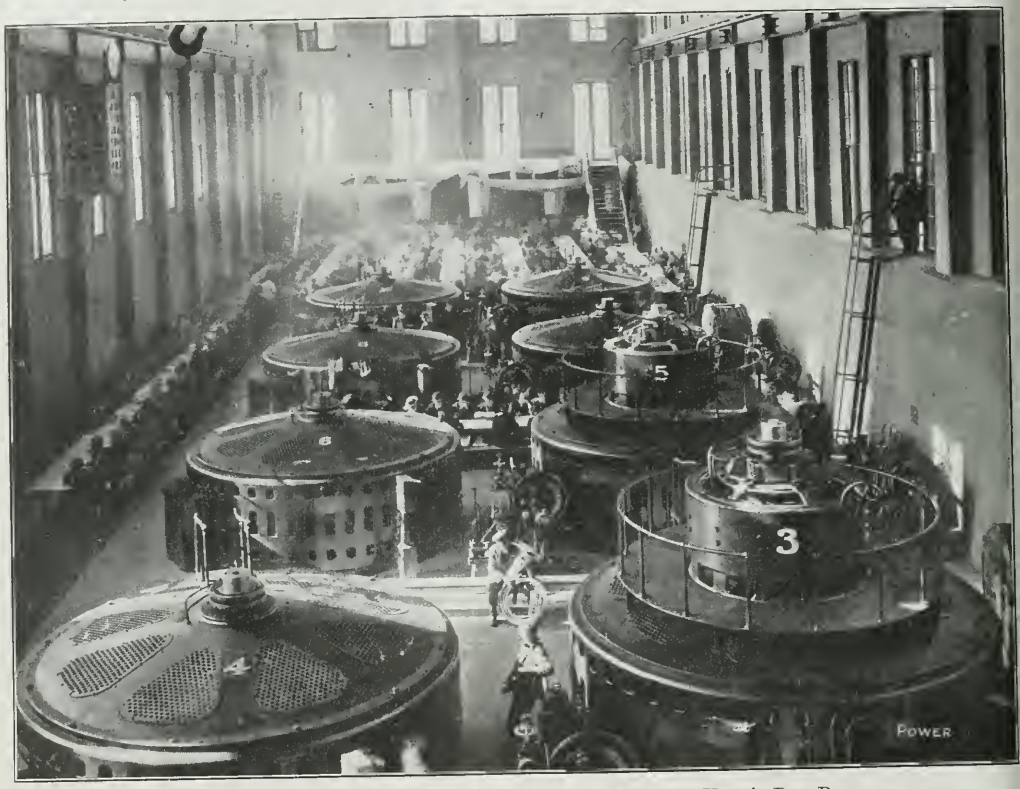


FIG. 1. DURING THE LUNCHEON IN THE TURBINE ROOM OF HALE'S BAR PLANT

hydro-electric development at that point and to establish the connection which should place at the disposal of those industries and others yet to come, a source of low-priced power which shall make Chattanooga, as its hustling Chamber of Commerce puts it, The Dynamo of Dixie.

Hale's Bar is only 12 miles from Chattanooga as the crow flies, but the river winds over 33 miles of country in its devious course through the mountains between these points. This 33 miles has been a stretch of precarious navigation with water enough to afford passage to sizable steamers only eight months of the year.

Dan C. Kingman, now chief engineer of the U. S.

privilege to Messrs. James and Guild, and they interested the late Anthony N. Brady in the project.

Col. John Bogart and Thomas E. Murray, of New York, were retained as hydraulic and electrical engineers and reported that Hale's Bar, some 17 miles further down the river, would be a preferable site, as it offered a foundation of solid rock and the river widened out at that point and afforded a better egress for the water in time of flood. A modification of the concession was obtained and work commenced at Hale's Bar in the fall of 1905.

Unforeseen difficulties developed in the progress of the work. Extensive clefts and faults in the bed rock re-

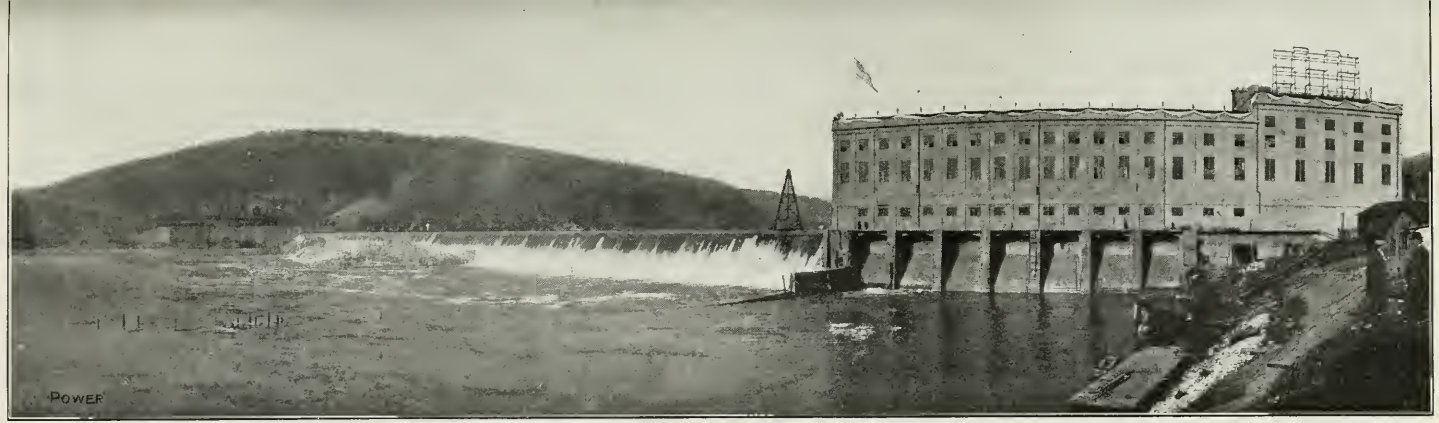


FIG. 2. POWER HOUSE DECORATED FOR FORMAL DEDICATION ON NOV. 13

FIG. 3. PANORAMA OF APPROACHES TO LOCK, THE DAM AND POWER HOUSE

quired sealing by the use of some 200,000 bags of cement, and many times the works were drowned out and swept away in the flood stages of the river. Several contractors tried it and gave it up. The cost mounted higher and higher above the estimate, but Mr. Brady stuck it out with his characteristic persistency and the one note of re-

FIG. 4. NORMAL FLOW OVER THE DAM

gret at the occasion which we are reviewing was that he did not live to see the work completed.

In several particulars this development is remarkable. The dam of cyclopean concrete is from 57 to 64 ft. wide at the bottom, 11 ft. at the top and 52 ft. in height. It is 1200 ft. long, and more water passes over it than over any other dam on a navigable river in the United States. The lock is built against a rocky bluff, has an inside length of 310 ft. and a maximum lift of 59 ft. The head upon the gates is greater than that upon those of the Panama Canal. They are constructed of steel and operated by electricity. Each leaf of the lower gates weighs some 129 tons.

The power house of reinforced concrete is located upon the right-hand bank of the river as one looks up stream and is 66 ft. wide by 353 ft. long. Of the length 220 ft. is one story high and contains the turbines and generators. The remaining portions, three stories in height, is devoted to the switches and transformers. The operating section is made up of seven bays, each designed to contain two units, ten of which are already installed.

Each unit consists of three Morgan-Smith turbines mounted upon a vertical shaft with the generator at the upper end. The two lower turbines are 72 in. in diameter, the upper 65 in. Under ordinary stages of the river only the two lower turbines will be used, the third coming into play when the river is in flood and the head reduced by back water. The head at low water is 39 ft., but at the 40-ft. stage of the river the backing up of the tail water reduces this to 19 ft. The turbines run at 112½ r.p.m. and each unit is capable of developing 5250 hp. with a head of 35 ft. The generators have a capacity of 3133 kw. each or 43,862 kw. for the completed station.

The current, generated at 6600 volts, 60 cycles, is stepped up in transformers to 44,000 volts for transmission to Chattanooga where it is expected that the available supply will be absorbed.

At the conclusion of the luncheon with which the visitors, who numbered some 500, were served upon their arrival at the power house, vice-president P. J. Kruesi, of the Chamber of Commerce, and chairman of the celebration committee, described the significance of the occasion in a brief address and introduced Governor Hooper, Mayor Thompson, Ex-senator Newell Sanders, Charles M. Jacobs, of Jacobs & Davies, the contractors, John A. Patten and others who spoke briefly of the meaning of the occasion to Chattanooga.

Finally the company stood at attention while the two little 7-year old grand-daughters of Mr. Brady, Ann Brady Gavitte and Jane Brady, threw the switches, which sent the current into Chattanooga. This event was made manifest to the Chattanoogan by the lighting of the thousands of incandescent bulbs with which Chattanooga's skyscraper, the James Building, named after the sole surviving promoter of the project, had been garlanded, and they stayed aglow all through the afternoon and evening, throwing an unaccustomed glare throughout the business district, typifying the wealth of power that there is now to spare and inviting all to come and partake of its ad-

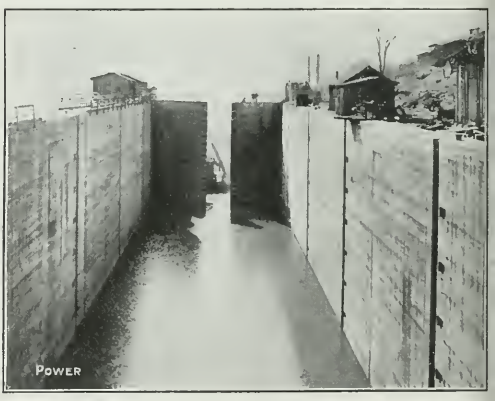


FIG. 5. LOCK AT HALE'S BAR, THE HIGHEST SINGLE LIFT IN THE WORLD

vantages. The current will be sold at the following rates in addition to a fixed monthly charge of $1 per kw. of maximum demand based upon the average of a 7½-min. peak load.

First 2000 kw	1½c. per kw.-hr.
Second 2000 kw	1¼c. per kw.-hr.
Third 2000 kw	1c. per kw.-hr.
Next 8000 kw	¾c. per kw.-hr.
All above 14,000 kw	½c. per kw.-hr.

Byron T. Burt will be the general manager of the plant.

The culminating feature of the day's celebration was a banquet ordered by the Chamber of Commerce to the visitors at the Signal Point Inn on the mountain of that

ie. Ex-senator James B. Frazier made a happy toast-ter, and appropriately commenced the postprandial reises by calling for a rising silent toast to the memory he man whose faith in the project and courage and sistency in its execution had made possible the event ch they were commemorating. Mr. Brady's two sons, the newly elected president of the American Institute of Electrical Engineers; Adolph S. Ochs, proprietor of the Chattanooga and New York *Times;* Charles M. Jacobs, of Jacobs & Davies, the contractors who successfully completed the work, and C. B. James, the parent of the project.

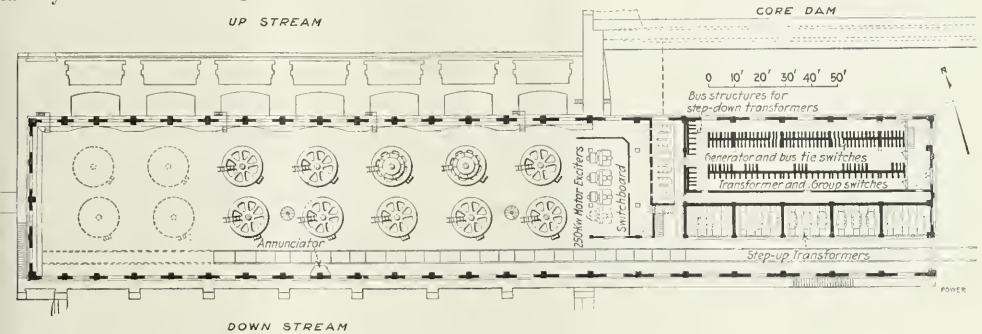


FIG. 6. PLAN VIEW, SHOWING LAYOUT OF POWER PLANT

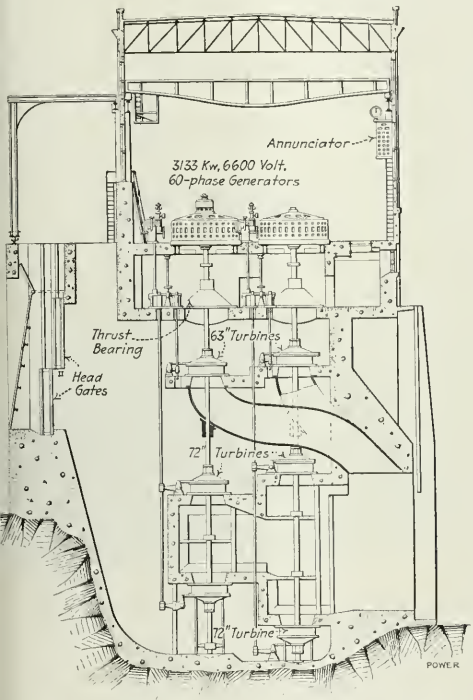


FIG. 7. TRANSVERSE SECTION, SHOWING THE THREE TURBINES ON ONE SHAFT

icholas F. and James C., were present. Toasts were re-ponded to by Chief Engineer John Bogart, Speaker E. . Allman, of the Alabama house of representatives, on ehalf of the governor of that state, Governor Ben W. ooper, of Tennessee, Thomas E. Murray, of the New ork Edison Co., who in addition to representing the rady interests was the representative of C. O. Mailloux,

When the industrial history of America is written this will be recorded as one of the earliest and most notable instances in which industry and commerce joined hands in an enterprise of magnitude which should conserve for the one, a mighty natural asset hereto worse than wasted, and open to the other new facilities for the transportation of the products of the first augmented in volume and value by the new power placed at its command.

No Coal after Eighty Years?

That the life of the anthracite industry in Pennsylvania is only 81 years, if the various estimates upon which he bases his average are correct, was the conclusion reached by M. S. Hachita, chemist of the Lehigh Valley Coal Co., in a speech made before the New York & Western Pennsylvania Coal Merchants Association.

The first estimate he quoted was that of the Geological Survey of Pennsylvania, according to which there were approximately 19,500,000,000 long tons in the ground prior to mining operations in that state. Taking an average of 40 per cent. as the proportion which can be extracted, this would leave 7,800,000,000 tons as the initial supply. Since 1820 the total tonnage mined has been 1,882,961,263, which would leave 5,917,038,737 tons still available.

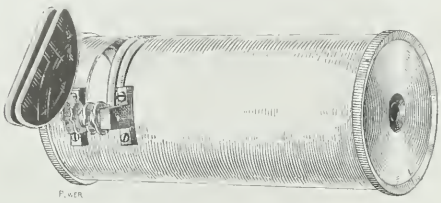
T. S. Harris estimated that there were originally in the ground 14,453,379,600 cu.yd., which is equivalent to 16,766,000,000 tons. By again taking 40 per cent. as the proportion which can be extracted and deducting the total amount mined, 4,823,438,737 tons are left available. A. D. W. Smith, one of the commissioners of the coal-waste investigation, estimated the available supply of anthracite in 1892 at 6,898,000,000 tons. Since then 1,141,684,910 tons have been mined, leaving 5,564,715,090 yet to be mined. In 1896, William Griffith estimated the available coal yet to be mined at 5,073,786,000 tons. Since then 1,096,963,635 tons have been mined, leaving 3,976,832,305 tons in the ground. The average of these four estimates by experts is 5,070,506,217 tons.

Dividing this by the probable consumption, gives the above number of years.

Standard Umbrascope Smoke Tester

This instrument has been designed to use in cities and towns where the smoke ordinances for the regulation of the density of smoke are in force. The method employed in determining the density of smoke is by comparison with smoked glass of certain light-absorbing power.

The tester, or umbrascope, which is manufactured by Williams, Brown & Earle, Inc., 918 Chestnut St., Philadelphia, Penn., consists of a nickel-plated tube, 1½ in.



Smoke Tester

in diameter and 4 in. long. Near one end of this tube are four smoked glasses, in the shape of half circles, so hinged that one or all of them may be swung into the tube at once, which clouds the view through one-half of the tube. The clear sky is viewed through the other half of the tube and through as many glasses of specified density as the law requires. A comparison between the glass and the smoke decides which is the darker.

The Miller Rotary Engine

Essentially, the Miller engine, Fig. 1, consists of a circular cast-iron cylinder in which two ring-packed pistons, cast integrally with a hollow disk, revolve. The disk, called the piston disk, revolves in the space between the two inside edges of the circular cylinder. Its sides

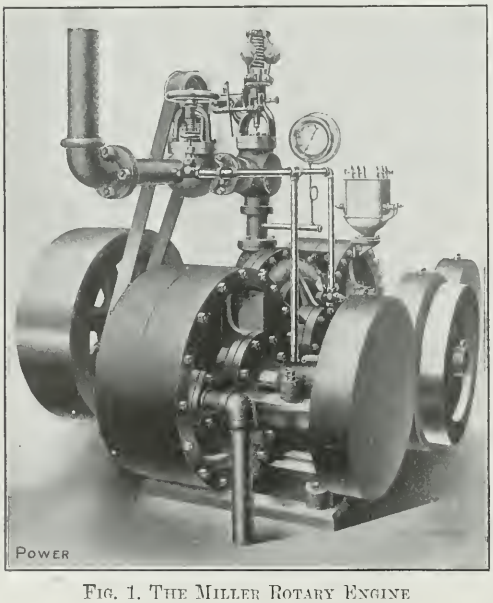


Fig. 1. The Miller Rotary Engine

are perforated to admit steam which gets into the cylinder by issuing through ports in the disk and bottom of the cylinder when the ports are opposite each other. This piston disk is packed against leakage into the cylinder by rings which may be set up against the disk by the set-screws.

The abutments, one of which is shown alone at the top of Fig. 2, resemble a pulley with a solid center, on the opposite sides of which are openings for the pistons to pass through, just as teeth of opposite gear wheels pass each other. As the piston comes through an abutment and the latter closes behind the piston, steam is admitted to the cylinder from the piston disk. The exhaust steam is swept out by the next piston. The effective stroke is the distance between the abutments, thus forming two curved cylinders; the rest of the circle occupied by the

Fig. 3. Diagrams from Top Half of Engine

abutments is used to exhaust the steam through the abutment openings and out the exhaust pipes connected to the abutment casings. The abutments are packed against the piston disk, all packing being metal and adapted to superheated steam. The design lends itself to compounding, condensing, to automatic cutoff and the engine may readily be made reversible.

The cylinder dimensions of the engine shown, which is noncondensing, are 3x21 in., and the machine is designed to develop 61.6 hp. at 800 r.p.m., and 150 lb. steam pressure. The piston speed at 800 r.p.m. is 4400 ft. per min.

As the effective stroke in one cylinder is 21 in. and each

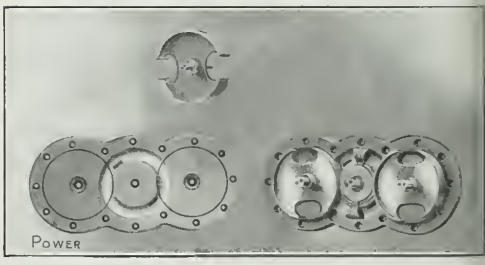


Fig. 2. Showing Cylinder Pistons and Abutments

piston receives two impulses per revolution, the total effective stroke is 84 in.

On the test by Professor Pryor at Stevens Institute the engine developed 52.2 b.hp., at 770 r.p.m., 140 lb. steam pressure, the steam consumption per brake horsepower being 64.1 lb. On a test of the same engine at Columbia University, F. F. Nickel obtained a steam consumption of 64 lb. per b.hp., with 90 lb. initial pressure, very wet steam, and at a speed of 667 r.p.m.

The indicator diagrams shown in Fig. 3 were taken with an ordinary reciprocating-engine indicator and the engine braked down to a speed of 100 r.p.m. The diagrams were taken from the top half or cylinder so that two diagrams were made, one for each piston.

The most economical speed of the engine is much below that of the turbine for the same power and considerably above that of the reciprocating engine, adapting it to various drives without gearing. The engine operates without vibration and is practically noiseless. As to weight, the engine is light per horsepower. The estimated weight of a 240-hp. engine, based on the weight of the present engine, is 4800 lb.

The inventor hopes to develop a rotary gas engine of the same general design.

The experimental engine was made by the Miller Motor Co., 132 East 237th St., New York City.

Tests of a Simple Noncondensing Lentz Engine

By Prof. J. A. Moyer*

Synopsis—Describes the method and results of four tests of a Lentz engine of 250 hp. capacity, which with about 155 lb. gage pressure and 140 deg. superheat, showed a steam rate between 15 and 16 lb. per hp.-hr., which means around 85 per cent. Rankine efficiency. So far as we know these tests establish a new record for simple noncondensing engines.

From July 30 to Aug. 6, 1913, I witnessed, as an entirely disinterested party, a series of tests, which were made on a simple horizontal Lentz engine, of which the cylinder diameter was $19\frac{1}{2}$ and the stroke was $20\frac{15}{16}$ in. These dimensions were taken by myself with accurate scales when the cylinder was hot. The piping arrangements for making a test of this engine for noncondensing operation are shown in Fig. 1. The exhaust steam was condensed in a battery of four closed feed-water heaters, supplied with cooling water from the city mains. The condensates were taken away in short pipe lines and discharged alternately into suitable weighing tanks on Fairbanks scales. For the purposes of this test these scales had been calibrated, corrected and certified by the Department of Weights and Measures of the city of Erie. The power from the engine was absorbed by a 300-kw., direct-current electric generator belted to the flywheel. The temperature and pressure of the steam at the engine were measured where the live-steam pipe entered the steam

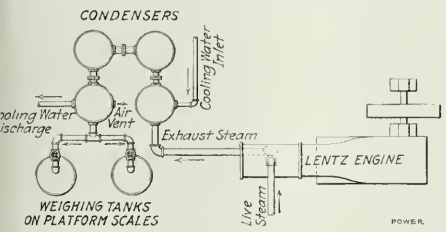


Fig. 1. Arrangement of Testing Apparatus

test. The speed of the engine was taken very accurately by a hand speed counter when the indicator diagrams were taken, and checked with the readings of a continuous engine counter. The current was absorbed in a large water rheostat arranged for accurate adjustment of the load. Readings were taken of ammeters and voltmeters in the power line to check the accuracy of the indicated horsepower determinations, assuming reasonable losses for the belt and generator. These electrical instruments were calibrated by the testing laboratories of the General Electric Co., just before starting the tests. Readings of all instruments were taken at 10-min. intervals and throughout all the tests the conditions remained remarkably constant even as regards the degree of superheat and the wattage absorbed by the water rheostats. This matter of the relative constancy of the readings of the ammeter between the 10-min. observations received my careful attention, so that I am certain that the conditions were uniformly good. The water supply of the feed-water heaters used as condensers

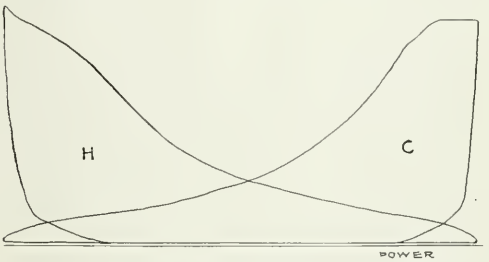


Fig. 2. Typical Diagrams from Lentz Engine

was carefully regulated so that all the steam was condensed. The air vent shown in Fig. 1 discharged into the testing room. If the steam had not been entirely condensed it would have been observed here.

One indicator was attached to each end of the cylinder with the shortest possible connection. These indicators were calibrated before the tests by their makers, again after the test by the Pennsylvania Engineering Experiment Station. The average of the two calibrations, which were in very good agreement, has been used in calculating the indicated horsepower. The areas of the indicator cards were measured with planimeters which have been checked for accuracy by the measurement of easily calculated geometrical areas. The special precautions enumerated above make the results of the calculated indicated horsepower of practically unquestionable accuracy.

As will be observed in the tabulated results, the most important tests were run with unusually constant conditions for periods of from three to four hours, so that the most skeptical should be convinced of the uniformity of the data and the accuracy of the results for long periods.

The thermometers used for determining the temperatures for both the live steam and the exhaust were carefully calibrated with standard thermometers and checked with the temperature given in the steam tables as corresponding with the observed pressures of saturated steam. Stem exposure was observed in all cases and the corre-

*Professor of Mechanical Engineering, Pennsylvania State College.

sponding corrections were made by the generally accepted methods.*

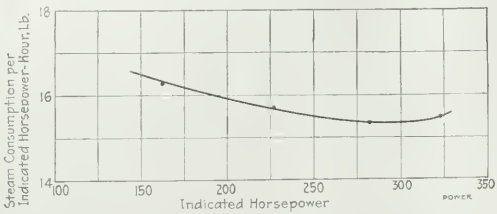


FIG. 3. RESULTS OF TEST OF LENTZ ENGINE

Fig. 2 shows typical indicator diagrams taken during the test.

The following table is a compilation of the important results of this series of tests:

RESULTS OF TESTS ON A SIMPLE LENTZ ENGINE

No. of test.	Duration of test, hours.	Speed, r.p.m.	Mean Effective Press., Lb. per Sq.In.** H.E.	C.E.	I.hp.	Steam per i.hp. per hour, lb.	Absolute steam pres., lb. per sq.in.	Back press., inches of mercury.	Superheat, deg. F.
1	4	208	46.35	45.92	282.1	15.24	170.3	0.34	141.5
2	3	208	24.83	28.40	162.7	17.25	170.1	0.00	98.3
3	3½	211	36.19	37.08	227.6	15.78	171.9	0.00	139.4
4	1†	207	53.40	52.22	322.5	15.48	171.7	0.10	159.7

**Calibrated scales of springs of indicators are respectively, 78.9 and 79.3 lb. per sq.in.

†Generator would not carry load for a longer time on account of heating.

It will be observed from the above table that the superheat for test No. 2, which was run at the lightest load for the series, could not be maintained as high as for the other tests on account of difficulties in boiler operation.

*"Power-Plant Testing," second edition, pages 36-38 (McGraw-Hill Book Co., New York).

In order to correct the steam consumption for this test and make it correspond as regards the amount of superheat with the others of the series, another set of tests was run during which full load was maintained on the engine and only the superheat was varied. A curve plotted from the results of these tests showed that the steam consumption was 6 per cent. lower at 147 deg.†† superheat than at 98. As the result of this correction the steam consumption of test No. 2 on the basis of the average superheat for the other tests is 6 per cent. less, or 17.25 — 1.03 or 16.22 lb. per indicated horsepower per hour. After making this correction all the tests are in very good agreement as regards superheat, back pressure and steam pressure. The final results as corrected for superheat are plotted on the curve shown in Fig. 3.

I believe these data indicate that this engine has shown the lowest steam consumption yet attained under satisfactory test conditions with a simple engine operating noncondensing, and that, therefore, the results are most important.

See brief report of tests in POWER, July 15, page 105, and criticism thereof by Mr. Hyde, on page 443, of Sept. 23.

Cleanliness and Efficiency in a German Power Plant

Economy, as regards fuel, is the one thing most sought after in German power plants, writers L. B. Webster in the American Gas & Electric Co.'s *Bulletin*. Coal, which can be laid down in plants in the United States for from $1.50 to $2.50 a ton, brings from $6 to $8 a ton, or even more, in Germany, where good fuel is not so plentiful as

††The average of tests 1, 3 and 4.

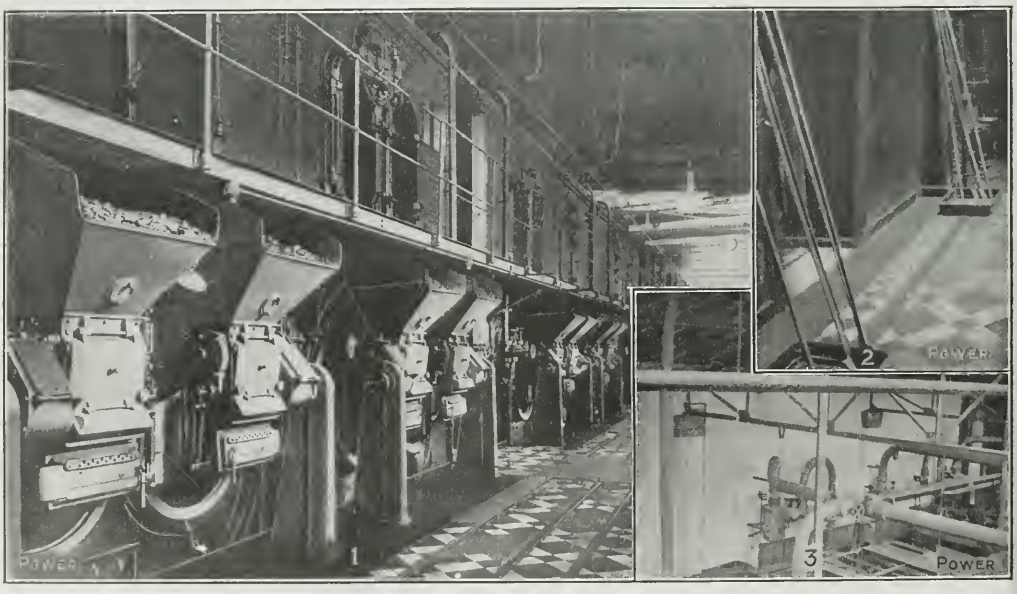


FIG. 1. VIEW IN BOILER ROOM. FIG. 2. HOW THE POKERS ARE CARED FOR. FIG. 3. SOME OF THE PIPING OVER THE BOILERS

it is in this country. As a result of the high price of fuel, coal and partly burned refuse are never seen scattered about, and every part of the typical German power plant is kept spotlessly clean.

In Fig. 1 is shown a view in the boiler room of the electric-light plant of the city of Munich, the capital of Bavaria, the largest and most progressive city in southern Germany. The boiler equipment of this plant consists of 32 internally fired boilers of 230 hp. each. These boilers are equipped with automatic stokers of the overfeed type; that is, the stokers throw the coal on the fuel bed in much the same way as a fireman does with a shovel. The work of firing, water tending and handling of reclaimed coal is done by a force of three men on each shift. In order for this small force to properly take care of such a large number of boilers, all equipment is arranged so that the men can do their work with the least possible expenditure of time and effort.

As an example of how carefully the operating problems in this boiler room have been worked out, Fig. 2 shows how the pokers and fire irons are cared for. Each pair of boilers has its complete set of pokers standing against the boiler-room wall in an iron tray, for the sake of keeping the boiler-room floor clean.

In Fig. 3 is shown some of the piping over the boilers and part of the main steam header along the engine-room wall.

Plenty of light and space have been provided over the boilers, where in so many plants in this country, the piping is often cramped and hard to get at. In Fig. 3, it is interesting to note, the piping is shown to be spotlessly clean.

Condenser-Tube Corrosion—I.

SYNOPSIS—The Corrosion Committee of the Institute of Metals has examined the question of corrosion by getting reports from operating engineers, by laboratory experiment, and by work on a small condenser plant. An abstract follows of their methods, and of such results as seem to touch most closely the operating engineer. The report is the work of Guy D. Bengough and Richard M. Jones.

It seems well to supplement the report of the committee on steam turbines of the Association of Edison Illuminating Companies, printed in the Oct. 14 issue, with a report of the work of the British Institute of Metals.

The time-honored method of investigation of this problem is to obtain information from the engineers in charge of condenser plants, and a number of blanks were sent out by the committee. The tubes on which reports were rendered were all 70:30 brass, or 70:29:1 tin alloy. The chief points of interest which could be deduced from the engineer's reports were:

(1) The extraordinary variation in the normal life of a tube, viz., from four to 25 years. Supplementary inquiries conducted by the authors have proved conclusively that tubes from the same batch made by one manufacturer, when placed in different parts of a condenser, might resist corrosion for times which vary up to the proportion of 1:3.

(2) The peculiar nature of the deterioration that resulted in the failure of the tube. In nearly every case the deterioration was due to dezincification, resulting in a rotten and pitted tube. In two or three cases tubes failed, owing to local thinning, due, apparently, to the wearing away of the whole body of the tube near the water-inlet end. This phenomenon was comparatively rare.

(3) The impossibility of correlating the failure of the tubes with the presence or nature of the electric-lighting installation.

(4) The difficulty of connecting corrosion with any definite locality in the tube or condenser, though it would appear as if thinning were connected with the ends of the tubes at which the cooling water entered.

(5) The shorter life of tubes in land installations, where dock, canal, or brackish water is used instead of sea water. Nevertheless, the Corrosion Committee, for good reasons, desired investigations in the first instance to be carried out with natural sea water, and this has been used in all experiments described, except where the contrary is stated.

Detailed examination of the scale attached to the tubes was made. In normal cases it could be regarded as made up of several layers of different composition.

The top layer consisted principally of ferric oxide, carbonates, and chlorides of calcium and magnesium, calcium sulphate and sand; the next layer consisted of basic chlorides and carbonates of copper and zinc, and was greenish in color. The layer next the tube was brown or black, and consisted largely of cuprous and cupric oxide. There was, of course, no sharp line of demarcation between the various layers, which faded gradually into one another, sometimes the greenish-blue layer was almost absent, especially when dezincification had been severe. In most cases the scale, particularly the lowest layer, was strongly adherent to the tube. In all cases, in which a tube had suffered dezincification the greenish-blue layer was replaced, to a greater or less extent, by a white flocculent salt, which was found to be a basic chloride of zinc.

In one or two cases tubes were received partially choked with a loosely adherent deposit, light gray in color. This was found to be principally sand, but contained also ferric oxide, magnesium salts, and calcium salts. Such tubes sometimes appeared to be more severely corroded than others taken from the same condenser, but not always.

Careful search was made among the deposits in badly corroded tubes for carbon particles. Although about a hundred cases were examined no such particles were ever found, and in no single instance could a dezincified spot or area be correlated definitely with such a particle. This, of course, does not prove that carbon in the form of graphite or coal had not started the dezincification of the tubes since it might subsequently have been removed when the tube was cleared by means of an iron rod or brush.

As a result of the study of the answers to the question schedules and of the tubes corroded under conditions of practical work, the authors came to the conclusion that few deductions of importance could be made, and that this method of work is only of value for indicating in a general way the nature of the problem to be attacked.

Laboratory Investigation

In arranging their somewhat extensive laboratory scheme the authors had to investigate two distinct forms of corrosion: "Complete" or the gradual wearing down of the tube, the copper and zinc being removed in the proportions in which they occur in the alloy; "selective," in which dezincification occurs, followed by pitting. The zinc is removed preferentially, leaving a rotten, copper-enriched area.

The tubes on which experiments were made had the following compositions:

		Condenser-Tube Compositions				
		Cu	Zn	Sn	Pb	Fe
I	70:30 Brass	70.20	29.17	....	0.27	0.27
II	70:28 Brass	69.94	27.60	....	2.08	0.28
III	61:39 Muntz Metal	60.90	38.21	....	0.46	0.33
IV	70:29:1 Admiralty Brass	71.18	27.28	1.07	0.28	0.21

In the first series of experiments, cleaned plates of these compositions were suspended by glass hooks in beakers of sea water, at ordinary room temperatures, 64 to 68 deg. F. The oxygen in the water was simply that which could diffuse in from the air. It soon became evident that the first stage of the corrosion of brass is the oxidation of one or both of the constituent metals. Cohen's observations are confirmed, *in the absence of oxygen there is no corrosion.* In this series of experiments, admiralty brass was most corroded; 70:28:2 brass next; 70:30 brass next; and Muntz metal least. The percentage losses after 208 days were for the four metals respectively:

Upper tubes	1.04	0.61	0.50	0.31
Lower tubes	1.02	0.55	0.45	0.27

The greater loss of the so called "upper tubes," the plates covered by the less water, is due to the greater amount of oxygen present in the upper layers of water. Experiments suggested by these results were made with aqueous solutions of carbon dioxide, and it was also determined that waters highly charged with this substance were corrosive to brass.

However, the result of these experiments at ordinary temperatures seems to be contained in this statement:

It has been suggested from time to time by engineers and others that sea water remaining stagnant in the tubes has a specially rapid corroding effect on them. Supposing no pitting to take place, and assuming that a tube could be used till it had lost two-thirds of its thickness, that corrosion takes place on one side only of the tube, and that it proceeds uniformly at the same rate, the life of a 70:30 tube should be about 75 years. In practice the life of a tube rarely reaches 25 years, and the normal life of a tube may be taken to be about 12 years under average conditions.

This corrosion by stagnant water is in all cases general and not selective.

Corrosion at Higher Temperatures

These immersion experiments were continued at higher temperatures, and one fact of predominating importance was immediately brought out: At 104 deg. F., brass tubes of any type are dezincified by sea water. The order of corrosion was: Muntz metal (least resistant), 70:30 brass; 70:29:1 tin; 70:28:2 lead. Dilution of the sea water tends toward selective corrosion; concentration of the sea water retards it. The effect of higher temperature is so marked that even at 77 deg., selective corrosion of 70:30 brass becomes evident after a few weeks, and only one of 20 different samples could remain in sea water at 104 deg. and not show signs of selective corrosion in a month.

At this temperature, loss in weight and corrosion by dezincification do not proceed *pari passu.* [The operating engineer should remember this in making tests of such alloys, as it is dezincification which will determine the giving away of the tubes.—Editor]. Thus, Muntz metal which is most readily dezincified loses least in weight.

Experiments at Higher Temperatures

Experiments were carried on at 122 deg. also, since observation of the outlet water on condensers in service showed that this temperature must often be reached at some points along the tubes. These experiments were run chiefly on the 70:30 and 70:29:1 alloys. The 70:30 tubes showed clear signs of dezincification after seven days' immersion; the 70:29:1 showed no signs at the end of six weeks. Since this alloy showed some slight signs in 104 deg. after three weeks, this result is remarkable, and indicates that there is only a limited range of temperature in which dezincification can take place. It appears that the presence of tin in the brass exerts a powerful effect in preventing selective corrosion.

The Experimental Condenser Plant

For a thorough examination under working conditions a plant was erected, consisting of a boiler working normally at 125 lb. per sq.in., a double-expansion engine, and a condenser, consisting of four sections, each of which contained 12 tubes. The sea water used was contained in an open tank and subject to free aëration, but not to contamination by rubbish; approximately its composition was: Sodium chloride, 2.81 per cent.; magnesium chloride, 0.21; potassium chloride, 0.17; magnesium sulphate, 0.11; calcium sulphate, 0.08; calcium carbonate, 0.02 per cent.

The tubes were of the same composition as those in the laboratory experiments. The vacuum in the condenser occasionally reached 25 to 27 in., but usually did not exceed 20 in. The steam condensed per hour was approximately 5 lb. per sq.ft. of condenser surface. The plant was closed after nine months' working, and three tubes removed from each section for examination.

Nature of the Scale

In all cases the tubes were covered with a brown layer, which consisted chiefly of ferric oxide; it contained also sodium chloride and calcium carbonate, as well as traces of sulphate. This layer was loose and easily removed from the tube. Beneath it a rather more adherent layer was found. This was greenish in color, and contained both copper and zinc in the form of basic chloride and carbonate. In places small white spots or particles of zinc oxychloride replaced the green layer, and the tube underlying these areas was found to be dezincified. In the case of the Muntz-metal tube, the green layer was normally absent and was replaced by a thin gray-white layer of zinc oxychloride. Beneath the layer of basic salts, a layer of brown or black oxide, strongly adherent to the tube, was found in all cases. In no case were any particles of graphite found amongst the scale. Evidently such particles as result from the dissolution of the cast-iron water ends are washed away in the stream of sea water.

Results of the Examination of the Tubes

Admiralty Tubes, 70:29:1

TOP TUBE—Dezincification in irregularly-shaped spots and areas, mainly along the bottom and sides of the tube, but extending for about 8 in. on each side of the center.

MIDDLE TUBE—Dezincification mainly along one side of the tube. Extends for about 6 in. from center.

BOTTOM TUBE—No signs of dezincification.

Special Brass, 70:28:2

TOP TUBE—Dezincification at sides only. Not very pronounced. Mostly near center of tube.

MIDDLE TUBE—A few scattered dezincified spots only. Distribution around tube irregular. Mostly near middle.

BOTTOM TUBE—No signs of dezincification.

Brass, 70:30

TOP TUBE—Dezincification in spots along bottom and sides of tube, extending a considerable distance from the center.

MIDDLE TUBE—In spots, mainly along bottom of tube. Interior surface of tube uneven and dezincification appears to take place on the raised portions.

BOTTOM TUBE—A large dezincified area at top of tube near center. Dezincification extends a few inches from center of tube.

Muntz Metal, 61:39

TOP TUBE—Severe dezincification in spots. In some places dezincification has almost penetrated through the tube. Especially noticeable along sides of tubes. Most severe near center.

MIDDLE TUBE—Numerous dezincified spots. One large

area 2 in. from center. Dezincification has penetrated one-third through the tube in one or two places.

BOTTOM TUBE—A few small spots at top of tube.

NOTE—The formation of a pit appears to take place in the following way: The zinc is removed from certain spots in the tube, and leaves behind the copper in a loose, spongy and rotten form. When dezincification has penetrated right through the tube, and the copper has lost its backing of unaltered brass, it is quickly worn away mechanically. Mechanical, and to a certain extent chemical, action also removes some of the copper even before dezincification has penetrated right through the tube. This is shown by the measurements of the depths to which the coppery area is depressed below the general level of the surface.

The most important deductions which the authors consider may be drawn from this series of observations are:

1. THE ORDER IN WHICH THE TUBES RESIST DEZINCIFICATION—The most resistant were the 70:29:1 and the 70:28:2 tubes. These appear to resist the action to about the same extent, and were considerably more resistant than the 70:30 brass, which came next in order of merit. The Muntz metal tubes were decidedly the most quickly attacked.

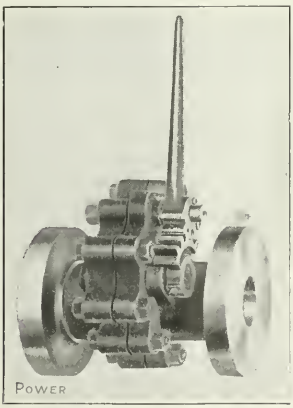
2. THE IMPORTANCE OF TEMPERATURE IN CORROSION PHENOMENA—In all cases the attack appeared to be most severe at or near the centers of the tubes. Since the steam entered the condensers at the center and no baffle-plates were used, the tubes must have been subjected to the highest temperatures at their centers. It becomes evident, therefore, that temperature plays a most important part in determining the distribution of the areas of dezincification.

3. CORROSION IS NOT CONFINED TO THE BOTTOM OF THE TUBES—It usually occurs in that position, but is by no means confined to it. It frequently occurs along the sides, and occasionally along the tops of the tubes.

4. GRAPHITE PARTICLES CANNOT BE REGARDED AS A CAUSE OF DEZINCIFICATION—Dezincification can occur independently of the presence of these or any other foreign particles.

Everlasting, Slow-Opening Blowoff Valve

One of the objections engineers have to straight-way, quick-opening, blowoff valves is that a careless, inexperienced fireman may close the valve so quickly as to produce water-hammer in the blowoff pipe.



SLOW-OPENING BLOW-OFF VALVE

The standard Everlasting blowoff valve is opened and closed by pulling the operating lever one-quarter turn. The slow-opening valve of the same type, also manufactured by the Patterson-Allen Engineering Co., 2 Rector St., New York, requires one-half turn of the lever to open or close the valve.

Referring to the accompanying illustration, the standard type of valve is fitted with a lever and pinion, which swing on a stud, secured to the body of the valve. The valve stem is provided with a rack, the teeth of which mesh with those of the pinion. Because of the difference in the diameter of the toothed circle, it is necessary to pull the lever through one-half of a revolution to fully open or close the valve, thus requiring twice the time to open or close it over the standard type of valve.

Rolling-Mill-Engine Flywheel Explosion

BY J. W. LEHMAN

The bursting of a 50-ton flywheel of a 1500-hp. engine at the American Rolling Mill Co., Zanesville, Ohio, fatally injured J. F. Kennison, day engineer, and will close down the plant for approximately 40 days. The accident took place at 11:55, a.m., Oct. 24.

Engineer Kennison, at the risk of his life, when the engine began speeding up, rushed to the throttle and had partly closed it when the crash came. He was buried under the débris and was later removed unconscious to a near-by hospital with a fractured skull and died later.

A gang of 20 men who were working near the engine quit work 25 min. before the crash. The flywheel was broken into small pieces. A part of the wheel, weighing approximately eight tons, was thrown a distance of 150 ft. A part of the roof was destroyed and the building was generally damaged. An investigation as to the cause of the accident is being conducted by the officials of the company. The engine proper was little damaged.

Reduced Condensation 76 Pounds per Hour

As a result in the kind of covering used on the steam pipes in the water-works plant of Middletown, Ohio, the condensation was reduced 76 lb. per hour.

According to the H. W. Johns-Manville Co., tests extending over a period of several months were made of the principal pipe covering and insulating materials, which resulted in an order for the J. M. asbestos-sponge felt pipe and boiler covering.

The efficiency of this pipe covering is accounted for by the millions of "dead air" cells it contains. Recent tests made by Prof. C. L. Norton, of the Massachusetts Institute of Technology, show that the yearly cost of maintaining 100 sq.ft. of pipe at 100 lb. gage pressure is, for bare pipes, $225; for 1-in. molded insulation, $35.90; and for 1-in. J. M. asbestos sponge $25.40.

This covering is made of many layers of thin felt composed of pure asbestos fiber and finely ground sponge. It is tough and flexible so that vibration, moisture, heat or rough usage will not cause it to break, crack, crumble or lose its insulating efficiency. It is fireproof and can be removed and replaced an indefinite number of times without deterioration.

The Largest Inland-Water Steamship—The "Seeandbee," a new side-wheel passenger steamer placed in service this summer between Cleveland and Buffalo, is the largest side-wheel steamer in existence. Five hundred feet over all, she has an extreme beam over the guards of 98.6 and a depth of hull at the stem of 30 ft. 4 in. The "Seeandbee" has six decks, and provides over 500 staterooms. She is driven by engines of 12,000 hp. at a speed of 22 miles an hour.

ELECTRICAL DEPARTMENT

The Induction Motor—IV

By F. A. Annett

Starting Devices for Squirrel-Cage Motors

Although the wound-rotor polyphase induction motor has the most satisfactory starting properties of any type, developing about 100 per cent. starting torque for 100 per cent. full-load starting current, other starting torques being approximate to the current taken until maximum starting torque is obtained, and can readily be used for variable-speed service. It is, nevertheless, inferior to the squirrel-cage type in every other respect. The cost is higher, the construction not so rugged, the efficiency, power factor, and pull-out point are lower and the motor itself requires more attention than the squirrel-cage type. For these reasons probably 75 per cent. of the polyphase motors in use today are of the squirrel-cage type.

One of the greatest objections to the squirrel-cage motor is the large current at low power factor taken from the line at starting. This heavy starting current is very objectionable for several reasons. If the motor is started on a lighting circuit the heavy starting current causes the lamps to flicker and if the motor is started very often this flickering of the lamps becomes very objectionable. The excessive current taken at starting may overload the prime mover and generator supplying the power or the

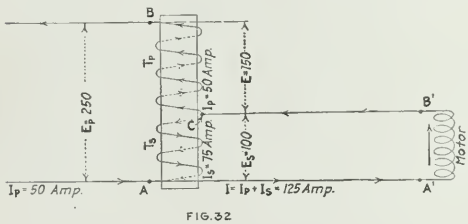


FIG. 32

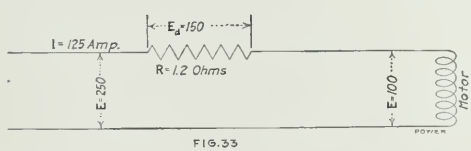


FIG. 33

Figs. 32 and 33. Representing Diagrammatically an Auto-Transformer and a Starting Resistance

transformers from which the motor is supplied, or the starting current may represent a large percentage of the total power transmitted in the feeder. This may cause an excessive drop in voltage which may affect other devices supplied from the same feeder. In some cases the heavy lagging current may cause synchronous devices on the same system to hunt.

To reduce the starting current and improve the starting torque of squirrel-cage motors various devices are used such as auto-transformers, rheostats and speci starting coils in the stator windings, the latter will explained later. Perhaps the most common is the aut transformer.

In sizes up to 5-hp. induction motors are usual started by connecting them direct to the line. In siz of 5 hp. and above an auto-transformer or starti rheostat is used. Some prefer the rheostat for starti small motors, and the auto-transformer for large ones.

An auto-transformer has but one winding for bo primary and secondary. This type of construction reduc the amount of copper used, depending upon the ratio transformation. Fig. 32 represents an auto-transform diagrammatically. Let it be assumed that the line pre sure is 250 volts and the transformer coil has 150 tur with a 100-volt tap taken off and as this tap will be a ratio of the primary volts to the secondary volts, t turns in the secondary can be expressed in the proportio Primary volts : secondary volts = total turns : seconda turns, that is, as 250 : 100 = 150 : secondary turns,

$$Secondary\ turns = \frac{100 \times 150}{250} = 60$$

Therefore, the 100-volt tap will include 60 turns of t coil and the voltage will be as indicated.

Assume that the current taken from the line by t motor is 50 amp. This current at a given instant w flow from terminal A of the line to terminal A' of t motor; from terminal B' of the motor to the low-volta tap C of the auto-transformer, through section BC the auto-transformer to terminal B, as shown by the a rows. The current flowing through section BC of t coil sets up a magnetic flux which induces an e.m.f. 100 volts in section AC opposite to the e.m.f. in secti BC so that the current in AC will flow opposite to t current in BC and will be in an inverse proportion the number of turns in each section of the coil, f theoretically the ampere turns (T_p) in the primary c must be equal to the ampere turns (T_s) in the seconda coil; hence the inverse proportion

$$T_s : T_p = I_p : I_s$$

Therefore,

$$I_s = \frac{T_p \times I_p}{T_s} = \frac{90 \times 50}{60} = 75\ amp.$$

which will flow in the direction as shown by the arro heads and combines with the primary current so there flowing through the motor a current of

$$I_p + I_s = 50 + 75 = 125\ amp.$$

although the generator is only required to supply 50 am

If a resistance was used to reduce the voltage inste of an auto-transformer, for the motor to have the sa starting torque it would have to receive 125 amp. fro the line at 100 volts impressed at the motor termina To get this condition a resistance that will cause a dr of 150 volts with a current density of 125 amp. mu be connected in series with the motor. This resistance

would equal the voltage drop divided by the current, or

$$R = \frac{150}{125} = 1.2 \text{ ohms}$$

This condition is shown in Fig. 33, and the generator has to supply 125 amp. to the motor instead of 50 amp. as

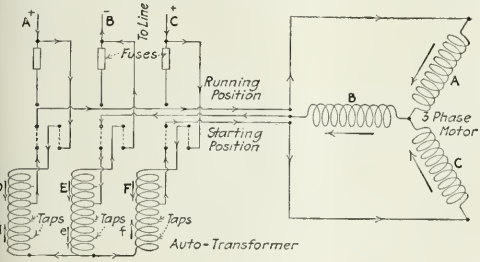


FIG. 34

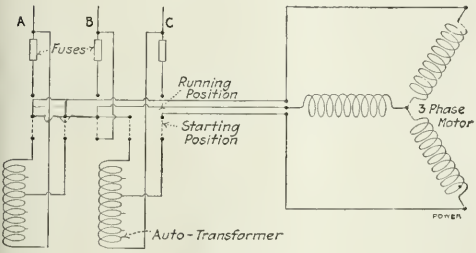


FIG. 35

FIGS. 34 AND 35. STARTING COMPENSATORS

when an auto-transformer was used. In the case of the resistance the watts loss equals the voltage drop across the resistance multiplied by the current, or

$$150 \times 125 = 18{,}750 \text{ watts}$$

The total power supplied by the generator when starting with a resistance is

$$EI = 250 \times 125 = 31{,}250 \text{ watts}$$

the difference between this and the watts lost in the resistance being the power supplied to the motor, or

$$31{,}250 - 18{,}750 = 12{,}500 \text{ watts}$$

With the auto-transformer all the energy supplied by the generator (except a small loss in the coils of the auto-transformer) was used in starting the motor, that is,

$$EI = 250 \times 50 = 12{,}500 \text{ watts}$$

From the foregoing it would seem that an auto-transformer has much superior starting properties to that of a rheostat, and this would be true if the power factor at starting were unity. However, the power factor is very low, and as the drop in the line is largely due to the wattless component of the current and not the power component, with either type of starter the wattless component is about the same. Therefore the line disturbance would be about the same in one case as in the other. The power component produces some drop and this is greater with the resistance type of starter, but is again offset by the lagging current required to set up the flux in the transformer core.

One feature that any starting device should possess to be entirely satisfactory is automatic adjustment of the voltage at the motor as it comes up to speed, and in this feature the resistance type of starter is superior. At the instant of starting the motor takes a maximum current from the line; this causes a maximum drop across the starting resistance, and as the motor speeds up it generates a counter e.m.f. which increases with the speed and the current decreases. As the current decreases the voltage drop across the resistance decreases and increases across the motor terminal. This will be made clear by again referring to Fig. 33. If the condition at the instant of starting is as shown with a starting current of 125 amp., the drop across the starting resistance is 150 volts with 100 volts impressed on the motor terminals. If after the motor has come up to speed the current decreases to 50 amp., the voltage drop (Ed) across the resistance will equal the resistance (R) multiplied by the current (I) or

$$Ed = RI = 1.2 \times 50 = 60 \text{ volts}$$

The voltage impressed upon the motor terminals will

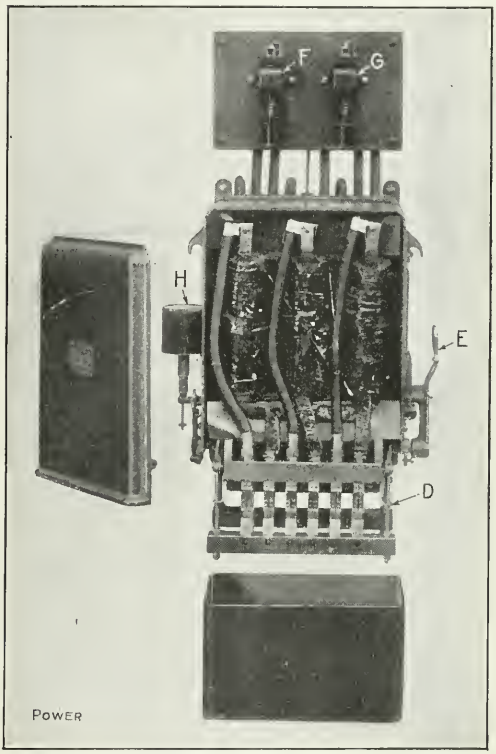


FIG. 36. G. E. COMPENSATOR WITH COVER REMOVED

equal the difference between the line voltage (E) and the drop across the resistance, or

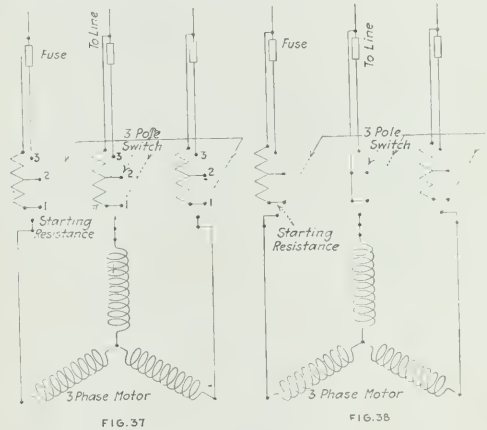
$$E - Ed = 250 - 60 = 190 \text{ volts}$$

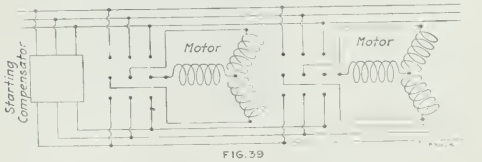
Therefore, the voltage has automatically increased at the motor terminals from 100 to 190; this is not possible with an auto-transformer, for the secondary voltage is fixed by the ratio of the primary turns to the secondary turns. Moreover, the resistance type of starter can be readily constructed with a number of intermediate steps. This

means that the voltage can be gradually raised at the motor and when the latter is thrown directly on the line the voltage change will not be so great, consequently, the current taken from the line will not be so great with its corresponding drop in line voltage.

The resistance starter is much cheaper than the auto-transformer, which is one reason for its use with small motors. As regards the power taken from the line at starting the auto-transformer is distinctly superior to the resistance type; hence a large percentage of squirrel-cage motors are started by this means, the resistance type being limited usually to sizes below 25 hp.

For starting two-phase motors two single-phase auto-transformers are used, one connected across each phase, and for starting three-phase motors two types of compensators are used, one using a three-phase auto-transformer with the three coils connected in star. Fig. 34 shows such a starting compensator and motor diagrammatically. At starting the switch is thrown to the position shown by the dotted lines. This connects the motor through the auto-transformer to the line beyond the fuses, which would be blown by the heavy starting current if left in the circuit. Assuming an instant when the line polarity is as indicated, that is, A and C are positive and B negative, then when the switch is closed current will flow from A and C through sections D and F of the auto-transformer through the motor winding and back through section E of the auto-transformer to the





FIGS. 37 AND 38. BALANCED AND UNBALANCED RHEOSTATS
FIG. 39. ARRANGEMENT FOR STARTING SEVERAL MOTORS FROM ONE COMPENSATOR

middle terminal of the line B, as shown by the arrows. This current flowing through sections D, E and F of the auto-transformer induces an e.m.f. in sections d, e, and f, opposite to the e.m.f. in sections D, E and F; therefore, a secondary current, having the direction shown will combine with the primary current and flow through the motor. This is identical to the conditions represented in Fig. 32, only in this case three transformers are used instead of one. After the motor comes up to speed the switch is thrown over in the opposite position and the motor is connected direct to the line through the fuses.

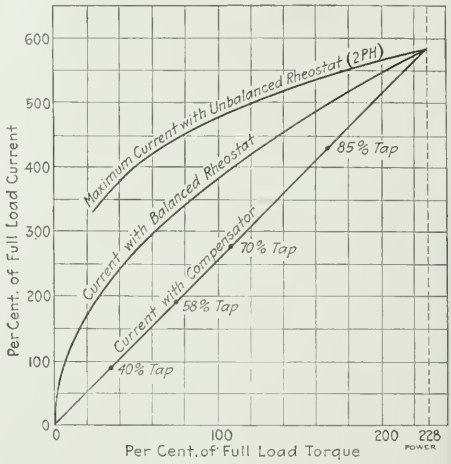


FIG. 38a. PERCENTAGE OF FULL-LOAD STARTING CURRENT REQUIRED AND CORRESPONDING TORQUE*

The second type of starting compensator used by several manufacturers to start three-phase motors is one that employs two auto-transformers connected in open delta. This type has the advantage that it can be used for starting either three-phase or two-phase motors. Fig. 35 shows such a starting compensator connected to a three-phase motor, the action being similar to that of Fig. 34.

Fig. 36 shows a G. E. compensator with the cover removed to show the various parts; in the center are the three coils of the three-phase auto-transformers. The double-throw switch D is operated by the handle E which is interlocking and cannot be thrown to the running position until first thrown to the starting position. Overload relays F and G protect the motor from overloads and may be replaced by fuses; H is a no-voltage release coil which when the line voltage fails releases the starting switch D and handle E and they come back to the off position so that the motor will not be started when the power comes back on the line, except by an attendant. The oil tank in which the switch D is immersed is shown at the bottom.

A motor that has to start under a heavy load will require a much higher voltage than one starting under light load and taps are usually brought out so that about 35, 50, 65 or 85 per cent. of the line voltage may be impressed on the motor terminals. With some starters, employing a drum switch immersed in oil, two or more voltage taps are brought into action in steps.

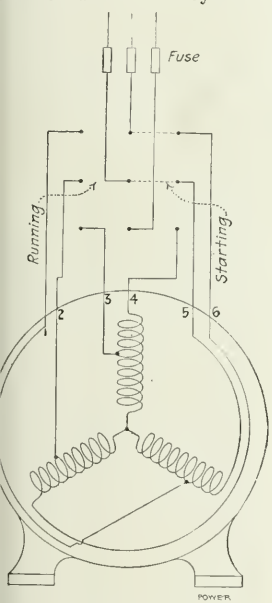
Two types of rheostats are used for starting three-phase squirrel-cage motors—the balanced and the unbalanced types, the former employs three resistances, one connected in each leg of the circuit, and usually arranged so that resistance can be cut out in equal steps, as shown diagrammatically in Fig. 37. The connections are made so that the fuses are out of circuit as with the auto

*By courtesy of the "General Electric Review."

ansformer at starting. For starting, the switch is thrown o position (1), which connects the motor to the line with ll the resistance in series; as the motor speeds up the witch is thrown to position (2), this cuts out one sec- on of the resistance in each leg of the circuit, causing further increase in speed. The switch is next thrown o position (3), which connects the motor direct to the ne through the fuses. Contacts (1) and (2) are ar- anged so that they are out of circuit when the switch s in the running position.

The unbalanced type has two resistances, one in each f two legs of the circuit, as shown diagrammatically in ig. 38. These are arranged so that they can be cut out f the circuit similar to Fig. 37. Although this type costs ss than the balanced type the starting current is much rger for a given starting torque and cannot be recom- ended except in cases where cost is of primary import- nce. The curves in Fig. 38a show the percentage of full- ad starting current required by a 20-hp. motor in the ree different cases in terms of the required starting rque. From the curves it will be seen that to obtain ll-load torque with the compensator the starting cur- nt is 260 per cent., and with an unbalanced rheostat 80 per cent., and with an unbalanced rheostat 475 per nt.

Any size of squirrel-cage motor within the capacity of n auto-transformer may be satisfactorily started from it, as the voltage applied at the motor terminals at starting is fixed by the ratio of the transformer and is, therefore, theoretically the same for a large motor as for a small one. It is general practice to furnish each motor with its own starting device but is sometimes convenient to arrange to start several motors from the same starting compensator. A scheme for doing this is shown in Fig. 39. In addition to the starting compensator (which must be of a capacity equal to that of the largest motor started by it) a three-pole double-throw switch must be provided for each motor. When the switch is thrown to the lower position the motor is connected to the line through the starting compensators, ter it has come up to speed the three-pole switch is rown to the up position, thus connecting the motor di- ctly to the line. The auto-transformer is then brought ck to the off position ready to start up any other motor sired.



IG. 40. SHOWING ADDITIONAL TURNS IN STATOR WINDING FOR STARTING

A squirrel-cage motor may be provided with additional turns in the stator windings for starting. The Richmond Electric Co. builds a motor of this type, as shown diagrammatically in Fig. 40. When the three-pole switch is thrown to the starting position all the turns in the windings are in series after the motor has come up to speed.

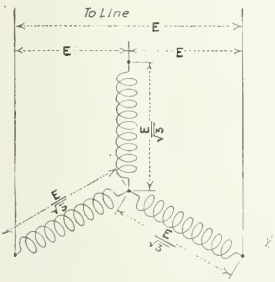


FIG. 41. THREE-PHASE STAR-CONNECTED WINDING

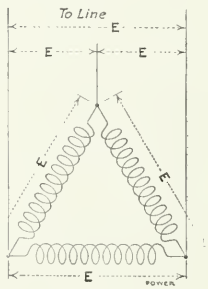


FIG. 42. THREE-PHASE DELTA-CONNECTED WINDING

The switch is then thrown over to the running position and part of the stator winding is cut out. To provide room for the starting coils the stator core and frame have to be made larger than otherwise.

Another method used in starting three-phase squirrel-cage motors is the star-delta method used by the Crocker-Wheeler Co. for starting motors of less than 30 hp. At starting, the three stator windings are connected in star, as shown in Fig. 41. The voltage across each winding is equal to the line voltage (E) divided by the $\sqrt{3}$ or about 57 per cent. of the line voltage; this is usually sufficient to start the motor under most conditions. When the motor comes up to speed the switch is thrown to the running position, and the windings are connected in delta, as in Fig. 42; this applies full-line voltage across each winding.

It should be mentioned that in some cases it is possible to bring out low-voltage taps from the neutral of the transformers supplying the power and by means of a three-pole double-throw switch 50 per cent. line voltage can be obtained for starting. This requires two sets of wires being run from the transformers to the starting switch at the motor. If the motor is some distance away from the transformers the cost of the additional conductors may be equal to or exceed that of a starting device.

The Largest Wood-Stave Pipe—The Northwestern Electric Co., Portland, Ore., has recently built for the conveyance of water what is probably the largest wood-stave pipe yet constructed. It is 13½ ft. in diameter, one mile in length, and it serves as the flow line from the dam to forebay. According to details given in the "Engineering News," there are ninety-four 4-in. staves around the circumference, the normal length of which is 18 ft.

The construction of this wood pipe line called for over 1,600,000 ft. board measure of Douglas fir, consisting of 1,000,000 ft. in the pipe proper, 476,000 ft. in the cradle and 210,000 in the mud sills. The staves were laid without tongue or groove, there being a steel dowel plate in one end of each stave to make tight the butt joints. The pipe was laid upon a bed of solid ground and, to stiffen it against distortion, it was carried in supporting cradles which were spaced about 4½ ft. apart on tangents, the saddles being carefully cut to the desired shape.

GAS POWER DEPARTMENT

Gas Engines vs. Steam for Pumping

Comparison on a commercial basis between a suction-gas-producer pumping-engine plant and a steam-engine plant operating under similar conditions is afforded in a paper by J. E. Gibson and S. H. Wright which was read before the Engineers Club, of Philadelphia, and appears in the *Proceedings* for October.

The gas plant belongs to the Delaware Water Co. and is situated at the head of tide water on Christiana Creek.

TABLE I FIXED CHARGES

	Gas Plant	Steam Plant
Management	$ 200	$ 200
Superintendence	920	920
Depreciation	1694	1,987
Sinking fund	1043	1,297
Interest	4095	6,491
Insurance	76	250
Taxes	263	327
Total	$8291	$11,472

It consists of two complete producer units rated at 110 hp. each and two 13x12-in., single-acting, three-cylinder vertical gas engines of 89 b.hp., each direct connected to a 13x15-in., single-acting triplex pump. The engines run at 265 r.p.m. and the pumps, through a 5 to 1 reduction gear, at 44 r.p.m., at which speed each has a capacity of 1,640,000 gal. per 24 hr.

The cost of the plant was as follows:

Building and property	$38,750
Producers and engines complete, including auxiliaries	13,000
Pumps complete	7,250
Piping, air chambers, etc.	4,500
Total	$63,500
Cost of plant per brake horsepower	$392
Cost of plant per million gallons capacity per 24 hr.	19,250

A high grade of anthracite pea coal is used, costi $5.10 per long ton delivered into the storage bins.

Steam Pumping Plant

The steam pumping plant belongs to the Octora Water Co., and is located on the Octoraro Creek, ne Quarryville, Penn. It consists of three 100-hp. retu tubular boilers supplying steam to two horizontal, cro compound condensing Corliss pumping engines, havi 18 and 32 by 30-in. steam ends and 10x30-in. water en delivering at a pressure of 150 lb. These engines run 55 to 60 r.p.m. and are rated at three million gall capacity. The cost of this plant was as follows:

COST OF STEAM PLANT

Building and land	$37,87
Boilers, engines, piping and auxiliaries	39,85
Total	$77,72
Cost of plant per brake horsepower, allowing 10 per cent. for engine friction	$19
Cost of plant per million gallons capacity per 24 hr.	$12,10

The fuel used is high-grade bituminous, costing $4 per long ton delivered at the plant.

TABLE II. OPERATING CHARGES

Item	1908 Plant Gas	1908 Plant Steam	1909 Plant Gas	1909 Plant Steam	1910 Plant Gas	1910 Plant Steam	1911 Plant Gas	1911 Plant Steam	1912 Plant Gas	1912 Plant Steam
Fuel	$609 22	$3497 78	$641.51	$3953.50	$1173.58	$4098.81	$1474.40	$4167.30	$1796.35	$4418.0
Oil, waste and packing	180 62	182.38	195.58	168.90	333.33	128.93	227.57	201.88	200.64	202.7
Building and machinery repairs	100.64	103 83	*280.07	14.00	†418.73	245.97	251.06	542.87	‡416.19	603.3
Pumping-station wages	1501.67	2529.60	1853.06	2412.15	2276 03	2309 88	2518.27	2180.00	2507.89	2382.8
Miscellaneous expenses	75.09	192.59	133.75	107.09	143.18	81.11	183 90	146.03	274.81	197.3
Total per annum	$2467.24	$6506 18	$3103.97	$6655 64	$4344 85	$6864 70	$4655.20	$7238.08	$5195.88	$7804.7

* Includes the replacing of spiral riveted purge pipes on producers, with cast-iron pipe.
† Includes spare parts for engines, such as inlet and exhaust valves, piston rings and piston, etc.
‡ Includes compromise settlement of claim for damaged castings that developed in producer in 1908, before the plant was finally accepted.

TABLE III. COMBINED FIXED AND OPERATING CHARGES

Item	1908 Plant Gas	1908 Plant Steam	1909 Plant Gas	1909 Plant Steam	1910 Plant Gas	1910 Plant Steam	1911 Plant Gas	1911 Plant Steam	1912 Plant Gas	1912 Plant Steam
Operating expenses	$2,467 24	$6,506.18	$3,103.97	$6,655.64	$4,344 85	$6,864 70	$4,655.20	$7,238.08	$5,195.88	$7,804.7
Fixed and overhead charges	8,291.00	11,472.00	8,291.00	11,472.00	8,291.00	11,472.00	8,291.00	11,472.00	8,291.00	11,472.
Total yearly cost	$10,758 24	$17,978 18	$11,394.97	$18,127.64	$12,635.85	$18,710.71	$12,946.20	$18,710.08	$13,486.88	$19,276.

TABLE IV. COST OF PUMPING ONE MILLION GALLONS 100 FT. HIGH

	Unit per Million Gallons Actually Pumped 100 Ft. High		1908 Gas	1908 Steam	1909 Gas	1909 Steam	1910 Gas	1910 Steam	1911 Gas	1911 Steam	1912 Gas	1912 Stea
Fixed Charges	Management	1	$0 995	$0 491	$0.589	$0.482	$0.318	$0.415	$0.301	$0.407	$0 293	$0 3
	Superintendence	2	4 590	2 265	2.715	2 215	1 465	1.908	1.381	1.875	1.345	1 7
	Depreciation	3	8 440	4.885	5.000	4 790	2 695	4 120	2 552	4 050	2 480	3 7
	Sinking fund	4	5.200	3 180	3.080	3 120	1 658	2.685	1.569	2.645	1.522	2 49
	Interest	5	20.400	15 970	12.080	15 620	6 500	13.440	6.150	13.230	5.980	12.2
	Insurance	6	0.379	0 615	0 224	0.602	0.121	0.519	0.114	0.509	0.111	0.4
	Taxes	7	1.313	0.803	0.787	0.788	0.418	0.693	0.396	0.666	0.400	0.6
	Total cost per annum	8	$41.317	$28.219	$24.475	$27.617	$13.175	$23 780	$12.463	$23.382	$12.131	$21.7
Operating Charges	Fuel	9	$2 615	$2 410	$1.441	$2.698	$1.291	$2 425	$1.505	$2.510	$1.860	$2.3
	Oil, waste and packing	10	0 775	0 126	0.439	0 115	0.366	0.076	0.232	0 126	0 208	0.1
	Pumping-station wages	11	7 490	6.210	5 470	5 825	3 615	4.790	3 787	4 450	3 670	4.5
	Machinery repairs and building	12	0 432	0.072	0 631	0.0095	0 461	0 146	0 256	0.327	0 431	0.3
	Miscellaneous expenses	13	0 322	0.133	0 300	0.0735	0 157	0.048	0 188	0.088	0 285	0.1
	Total cost per annum	14	$11 634	$8.951	$8 281	$8 721	$5.890	$7 485	$5.968	$7.501	$6.454	$7 3
	Total of Operating and Fixed charges	15	$52 951	$37 170	$32 756	$36 338	$19 065	$31 265	$18 431	$30 883	$18.585	$29 0
		16	Average cost of pumping 1 million gal. 100 ft. high—gas									$2
		17	Average cost of pumping 1 million gal. 100 ft. high—steam									3

The overhead charges for the two plants are given in Table 1. The management and superintendence are taken the same for both cases, but owing to the larger capacity, and hence greater first cost, of the steam plant, its total fixed charges are greater. In figuring the depreciation, however, the life of the gas-engine plant was taken as 15 years as against 20 years for the steam-engine plant. This does not apply to the buildings which were in both cases considered to have a 35-year life.

The operating charges for the past five years for both plants are given in Table 2 and the combined operating and fixed charges in Table 3. The fixed, operating and total costs reduced to a basis of pumping one million gallons 100 ft. high are given in Table 4.

The items on lines 1 to 7 inclusive and 11 were obtained by dividing the annual cost for those items by the actual number of million gallons pumped for the year, as these charges were independent of the pumping head.

From Table 4 it will be seen that for 1908 the total cost for operating the gas plant was considerably greater than the steam plant. This was because for the first year only one pump was operated for only part of the day. The consumption has now reached the point where it is found advisable to operate one pump continuously and the second pump several hours each day. In justice to the steam plant it should be noted that, owing to its larger capacity, its load factor is less than the gas plant.

❋

Mean Effective Pressures

In the issue of Oct. 14, under the heading "Horsepower of Small Gas Engines," it is stated that the full-load horsepower may be estimated by assuming a mean effective pressure. This is true, but it might be well to go into detail and tell how this assumption is made. I have, therefore, added several well known methods of determining values of mean effective pressure.

Grover's Method

This was determined by examining a large number of indicator diagrams, neglecting the effect of the kind of fuel or the quality of the mixture. By this method, $M.E.P. = 2C - 0.01C^2$, where C is the compression pressure in pounds per square inch absolute. According to this, the mean effective pressure increases up to a maximum at 100 pounds per square inch gage, beyond which it decreases, giving results which are of practically no use.

Moss' Method (Power, July, 1906)

Here the author not only considers the kind of fuel, but also considers the size of the engine. The mean effective pressure will increase with the engine size on account of the relatively less cooling loss in large than in small engines; rich mixtures may also be expected to give higher mean effective pressures. Moss' table for values of mean effective pressure are as follows:

MEAN EFFECTIVE PRESSURES, POUNDS PER SQUARE INCH.

Compression Pressure Lb. per Sq.In. Gage	Probable Clearance as Per Cent of Displacement Volume	Approximate Brake Horsepower of Engine						
		5	10	25	50	100	200	500
50	40	60	65	70	75	..	..	..
60	35	65	70	75	80	..	..	..
70	30	70	75	80	85	85	90	95
80	28	70	75	85	90	90	95	100
90	26	..	..	90	95	95	100	105
100	24	..	..	95	95	100	100	110
110	22	..	..	95	95	100	100	110
120	20	..	..	..	..	100	100	110

In the foregoing table, only four-stroke-cycle engines are considered and the fuel is assumed to be average natural gas or illuminating gas. If some other fuel is used, a correction factor should be supplied from the following table:

RATIOS OF HEAT OF COMBUSTION PER CUBIC FOOT OF PERFECT MIXTURE TO THE VALUE FOR AVERAGE NATURAL GAS OR ILLUMINATING GAS

Fuel	Correction Factor
Oil gas	1 00
Water gas (uncarbureted)	1 00
Coke-oven gas	0 93
Air gas (Siemens producer gas)	0 79
Water gas (carbureted)	1 05
Anthracite producer gas	0 80
Bituminous producer gas	0 87
Blast-furnace gas	0.67
Acetyline gas	1.28
Gasolene	1 12
Kerosene	0.90

Güldner's Method

This is based upon the following two well known facts: (1) Power depends upon the volume of mixture handled in a unit time. (2) Power depends upon the thermal efficiency with which the engine can handle the volume. The first involves cylinder dimensions and revolutions per minute, and fixing any two determines the third. The only assumption made is that of volumetric efficiency, and due to such large amounts of experimental data being available, no great error can be made regarding this point; the same being true for thermal efficiency and fuel characteristics. Güldner's formula is

$$B.hp. = \frac{n \times e \times l \times H \times d^2 \times Ev}{108 \times L}$$

Where

n = Revolutions per minute;
e = Thermal efficiency;
l = Stroke in feet;
H = Heat value of fuel in B.t.u.;
d = Piston diameter in feet;
Ev = Volumetric efficiency of suction stroke;
L = Cubic feet of air required for one cubic foot of gas fuel.

To L, e and Ev values must be assigned, and with such an abundance of practical data available, no difficulty should be experienced in that direction.

A. L. A. M. Formula

B.hp. $= d^2 N/2.5$, where d is the cylinder diameter in inches and N is the number of cylinders. Since the term 2.5 results from the contraction of several arbitrarily assumed factors, the formula is of no use whatever as far as design is concerned.

Rice's Formula

$$B.h.p. = \frac{d^2 \times l \times N \times n}{14{,}000}\left(0.48\,\frac{1}{10\,Cl}\right)$$

where

d = Cylinder diameter in inches;
l = Stroke in inches;
N = Number of cylinders;
n = Revolutions per minute;
Cl = Clearance in terms of piston displacement.

By using the foregoing formulas to solve the same problem, it will be found that the results vary so as to make it difficult to predict with accuracy the values of mean effective pressure and horsepower.

M. A. Ticker.

Newburgh, N. Y.

HEATING AND VENTILATION

Special Ward Heating and Ventilation

By H. S. Knowlton

The Peter Bent Brigham Hospital, a group of fifteen new buildings near the Harvard Medical School, Boston, is one of the most modern institutions of its kind in the country. The facility with which patients in bed can be rolled out of doors, the provision for natural lighting, sanitation, steam and hot-water systems, and floor-warming coils under certain ward rooms are interesting features. The heating and ventilation plant was designed by Densmore & LeClear, mechanical engineers, Boston, and in the following paragraphs are given the principal features of heating and ventilation employed in a typical ward building.

Heating and power service are supplied from the adjacent plant of the Harvard Medical School through an 8x8-ft. reinforced-concrete tunnel. A typical ward building accommodates 40 patients. There are three general wards, the octagonal room *A* and the ward *B* on the first floor, and ward *E* on the second, with 14, 8 and 12 beds respectively, and five special wards with one and two beds each. The general arrangement of the heating and ventilating system is shown in Figs. 1 and 2. The heating is mainly by hot-water radiators connected to a two-pipe under-fed system. Wards *A*, *B* and *E* are heated and ventilated, and the smaller wards are ventilated by the introduction of fresh air on the plenum system. Diet kitchens, duty rooms and other places from which odors may come are ventilated by the use of exhaust fans. Hot-water heating was selected on account of its quietness of operation and uniformity of temperature control secured. Fig. 1 shows the general arrangement of heater, screen and fan rooms in the basement of a typical ward.

The cold air entering the heater room passes through the first two groups of a stack of 1134 sq.ft. of heating surface, the groups being valved separately for partial regulation. A portion of the air flows through the two remaining groups, and the remainder is bypassed through a mixing damper, whence it passes to the upper portion

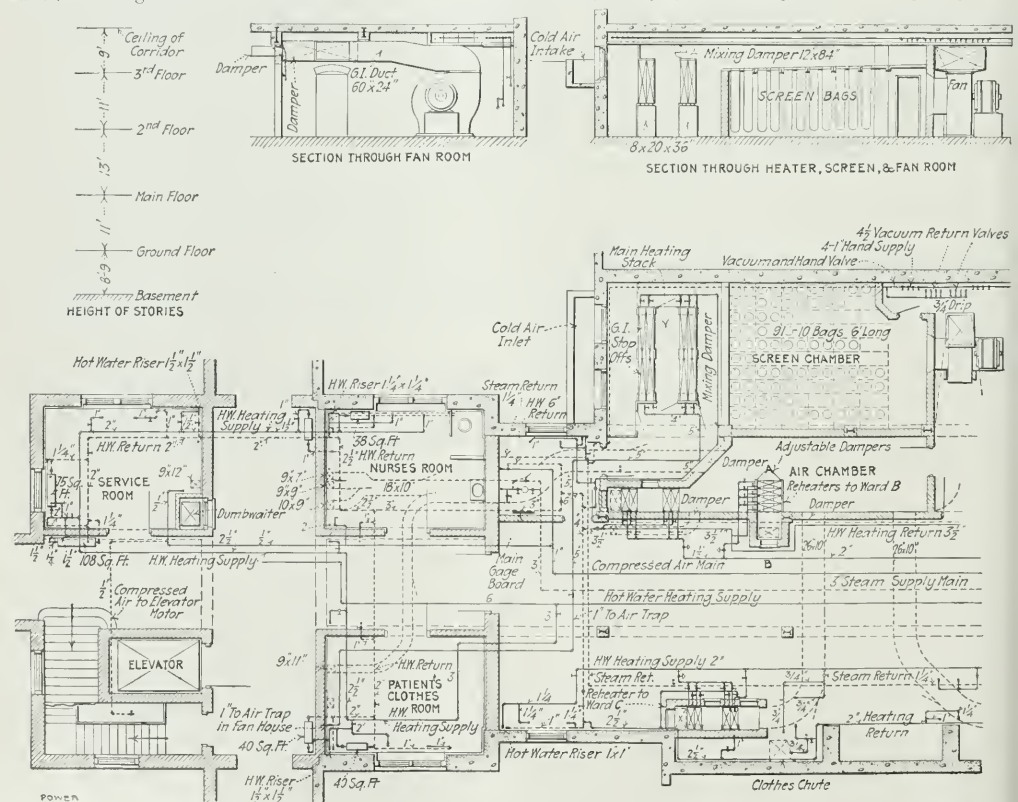


Fig. 1. Plan of Piping and General Arrangement of Heating and Ventilating System

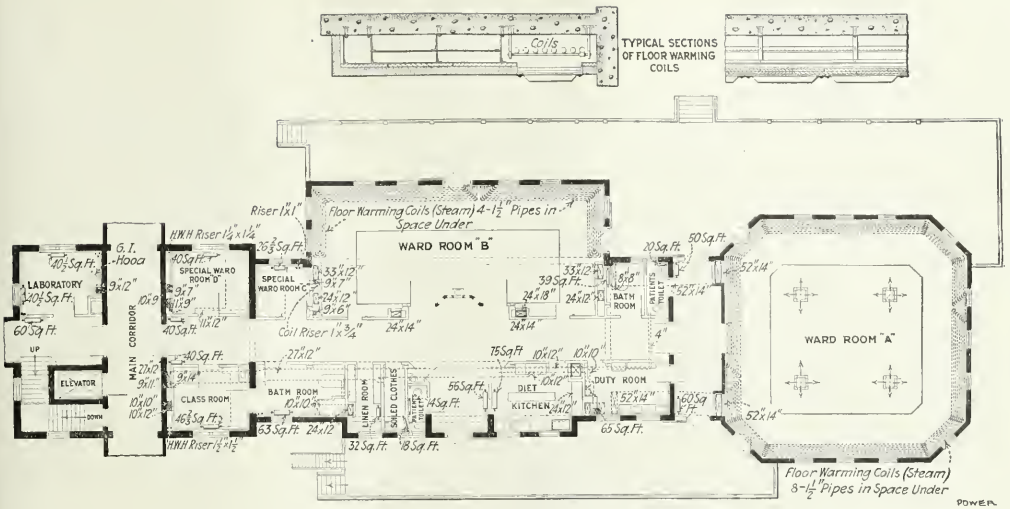
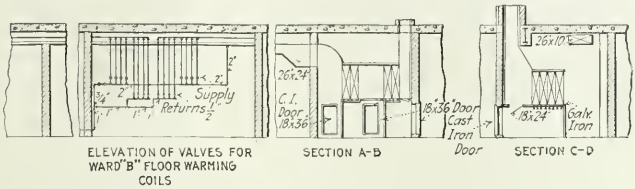
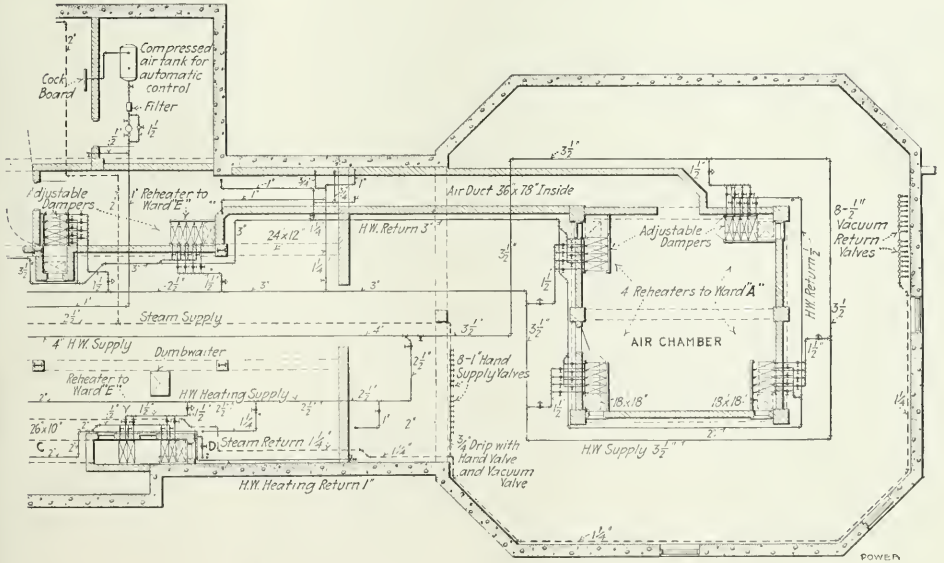


FIG. 2. FIRST-FLOOR PLAN OF PETER BENT BRIGHAM HOSPITAL





A CONTINUATION OF FIG. 1, SHOWING SOUTH HALF OF BUILDING

of the screen chamber where it is drawn through dust bags and enters a No. 9 Sturtevant multivane fan with a capacity of 17,100 cu.ft. per min., driven by a 6-hp. motor with a speed range of from 171 to 284 r.p.m. From the fan room the air is forced through a galvanized-iron duct branching into two air chambers, one on either side of the entrance to the fan room. An adjustable damper is located at the bifurcation. One of the air chambers is connected by a 36x78-in. horizontal masonry duct with a square air chamber under ward *A*. At each of the four corners of the latter is a reheater containing 215 sq.ft. of heating surface, giving a total of 860 sq.ft. of reheating surface for the octagonal ward. There are also four similar reheaters, two in either air chamber adjacent to the fan and heater rooms, two each serving wards *B* and *E*. Ward *E* has two additional reheaters, each containing 215 sq.ft. of surface, located at the west wall of the basement, supplied by 26x10-in. ducts.

A system of galvanized-iron ducts connecting the air chamber adjacent to the heater room with riser ducts supplies a classroom, and special ward rooms at the northern end of the building. Adjustable dampers are installed at the branches of the ducts and at the lower ends of the riser ducts leading from the air chamber. Fresh air enters ward room *A* through four 18x24-in. registers placed in the sides of square concrete supports about 3 ft. in height, spaced at the four corners of a square in the center of the room above the reheaters on the floor below. This arrangement gives an even distribution of air throughout the ward. Two 52x18-in. outlets are located near the ceiling in the partition wall, one on either side of the doorway.

Ward *B*, situated on the east side of the corridor in the central portion of the building, is served by two 24x14-in. inlet ducts in the corridor wall, and two 33x12-in. outlet ducts in the wall at either end of the room. Ward *E*, occupying the full width of the southern end of the building on the second floor, is supplied by four 24x12-in. riser ducts placed in the end walls near the corners. The exhaust ducts from wards *A*, *B* and *E* are carried into four vents fitted with an aspirating steam coil of 15 sq.ft. of surface, discharging into the open air above the roof over ward *E*.

Monitors over wards *A* and *E* ventilate the rooms when the indirect heating plant is not in use. The ventilation system provides for five changes of air per hour in the classroom and all the ward rooms except *A* and *E*, which are supplied with 4.53 and 5.86 changes per hour respectively. The above figures, in terms of cubic feet per hour per patient, give 12,400 for ward *A* and 11,000 for ward *B*. All toilets are ventilated at the rate of 1500 cu.ft. per hr. per fixture. Inlet and duct velocities are 6 and 5 ft. per sec., respectively.

Steam coils, as shown in Fig. 2, are placed in a dead space under the floors around the outsides of ward rooms *A* and *B* for the purpose of warming the concrete floors under the beds. Battleship linoleum covers the central portion of these rooms but does not extend under the beds. The coils, consisting of 1½-in. pipes, are placed at one side of an inclosed area about 1 ft. high and 8 ft. wide, and are supported by hangers midway between the top and bottom of the space. Two of the sides are formed by the basement ceiling and the walls, and the other two sides are made of No. 20 galvanized iron supported by 1½x1¼-in. hangers and lined with a layer of four-ply, 1-in. thick air-cell blocks with cemented joints. To establish a circulation of warm air, partitions or baffle-plates made of No. 20 galvanized iron have been placed alongside of the coil of pipes attached to 1x1-in. angle irons secured to the hangers. A portion of the casing under the coil of pipes is made removable by covers, in sections, insulated by two layers of air-cell blocks. The galvanized-iron bottom and sides are coated with plaster.

A 6-in., hot-water-heating supply main enters the building from the tunnel branches near the entrance supply the main stack and risers leading to radiators in the rooms at the northern end of the ward. The main runs the length of the basement, encircling the air chamber under ward *A*, delivering to the four reheaters, and returns parallel to itself supplying risers and reheaters in the air chamber near the fan room. It is reduced in size from 6 to 1½ in. at the last reheater. A branch feeds the two ward *E* reheaters, and risers in the central portion on the west side of the basement. The hot-water-heating return line, 1½ in. in diameter, begins at one of the ward *A* reheaters, then runs along the building toward the tunnel, tapping the return drops and the reheaters in the air chambers near the fan room, reaching a maximum diameter of 6 in. A branch of the return main starting on the west side of the basement near the octagonal end, connecting with return drops and reheaters, joins the return main near the entrance to the tunnel; a second branch from the northern end also connects with the main at this point.

A 3-in. pipe taken from the hot-water heating main in the basement of ward *C* building serves as an expansion pipe for the system, and is carried to the roof space adjacent to the fan room, the high point of the entire system, and connects with the bottom of a steel expansion tank 4 ft. in diameter and 9 ft. long. The tank is fitted with a 1¼-in. drawoff, and a 2-in. vapor pipe leading through the roof. A 3-in. overflow pipe with a 2-in. relief valve runs from the top of the tank to the basement and connects with the water drain outside the building. All the other buildings heated by hot water are fitted with a 1-in. pipe leading from a high point in the basement piping to the roof and vented through an inverted Foskett and Bishop trap, discharging air instead of water. Steam at boiler pressure enters the building through a 2-in. line, and is reduced to 5 lb. per sq.in. by a reducing valve which is bypassed. A 2-in. steam main runs along the basement, and branches supply the floor-warming coils for wards *A* and *B*. Hand valves are fitted to the supply end of each pipe comprising the coils, and vacuum valves are installed on the return end of such pipes; also a hand and vacuum valve are fitted on the drip of the horizontal supply pipe feeding the riser pipes of the coils. The Johnson service system of temperature control is used in all wards.

In general throughout the hospital, inlets are located near the ceiling and outlets near the floor. Only a few registers have been installed on account of the difficulty of keeping them free from dust. A grill is placed in each inlet duct, of diagonal 2-in. mesh of No. 10 wire with a channel-iron frame resting on angle-iron supports, and all cold-air openings are grilled. Ducts and flues are designed to avoid friction by the use of sweeps and curves where changes in direction occur. Sturtevant fans are used throughout. The heating contractor was the Cleghorn Co., of Boston.

EDITORIALS

Safety First

The above has been adopted as a slogan by many industries, and various conventions have met and are meeting to promote the idea among manufacturers that it is not only humane but economical to prevent accidents to employees rather than settle for the consequences. Protections of every conceivable nature are being invented to prevent gears, belts, wheels and every part of rapidly moving machinery from causing the accidental injury of those employed in their vicinity.

Notwithstanding the strenuous efforts that are being made to protect machinery, it is said to be proved by statistics, that only twenty per cent. of the industrial accidents can be laid to faulty machinery, the balance being due to carelessness or thoughtlessness on the part of the injured, or the carelessness of some fellow worker. To avoid these accidents, the education of the employee as to how he may protect himself and his fellow worker from the inherent dangers of his occupation, seems to be the only solution. POWER has repeatedly called to the attention of its readers one of the dangers incurred by boiler cleaners, repair men and inspectors who may be required to enter boilers that are connected by pipe lines to other boilers under steam; but the subject is of such importance that it will bear repetition, and especially at a time when a wave of "safety first" seems to be sweeping the land.

Have you ever stopped to think how helpless the man inside the boiler is to protect himself? It is impossible for him to watch the acts of his fellow workers to see if they are likely to jeopardize his safety, and, in fact, he is reduced to one sense, that of hearing, to afford him protection; and receiving a warning by sound is of the most doubtful aid, in avoiding the accidents that are likely to occur. The inspector may be ever so careful and thoroughly examine the valve on every connecting pipe that may become a source of danger, before entering the boiler, only to have all of his precaution set at naught by some meddler or employee who is ignorant of his presence in the plant.

Owners should provide locks for all valves that can admit steam or hot water to a boiler under repair or inspection, and it should not be forgotten that the blowoff valve is one of the most serious menaces to safety, when all blowoff pipes connect to a single main. When a boiler inspector visits a plant for the purpose of making an internal examination of a part of the boilers while the others are under steam, it is not unreasonable for him to expect an attendant to follow his movements while inside the boilers to protect him from possible danger.

While inside one of a battery of extremely hot boilers in the Pittsburgh district one Sunday morning a number of years ago, the writer heard a scuffle on the firing floor followed by a long string of very effective Irish oaths. Coming out of the boiler to learn the cause of the commotion, the Irish engineer was found still menacing a Hungarian laborer who was laying on the coal pile drenched in oil. The engineer had knocked down the Hungarian in the act of "heaving" three gallons of crude oil into the bottom manhole of the boiler just vacated. Had the engineer lacked the ability to think and act at the same time, there would have been registered another fatal boiler accident with the writer playing the rôle of corpse.

If a boiler requires repairs that necessitate the presence of men in it for several days, the pipe connections should be broken at a flange and blanked off. If the boiler is to be entered for only a short time for cleaning or inspecting, the valves should be locked and a sentinel placed on guard while men are inside. If an accident happens under such conditions, the owner or one responsible for taking precautions will have a clear conscience, also a clean record before the coroner.

Compensating Long Service

A certain operating engineer gave forty-eight years of loyalty and good service to his company. Then his employers, for no given reason, summarily dismissed him. No fault had been found with his ability—he was mentally and physically unimpaired—but the company had entered into no agreement with him beyond the stipulated wages; he was worth to the company just so many dollars and cents; it had profited by the account but concluded to close it. Rather a narrow standard of appreciation, isn't it?

If this engineer had been in the employ of the Pennsylvania R.R., for example, he would have been pensioned, his name placed on its roll of honor, and his half century of service made public. This company knows the exceeding value of loyalty, for its business creed contains an article which says that the company securing the loyalty of its men secures better service; "the creator of loyalty is a public benefactor."

In this company's recent bulletin it is stated that from three men it received one hundred and fifty-four years of loyalty and faithful service. These men were retired with a life pension and placed on the road's roll of honor, which contains four thousand and seven living persons.

Where is the operating engineer's roll of honor, his substantial recognition of a lifetime of service and loyalty?

The industrialists claim that "as the humanistic side of civilization has made progress, we have attained higher ideals regarding industry"; that the mere daily wage of dollars and cents is inadequate recompense. There are many who will take issue with the industrialists in the matter of ideals in our particular field of endeavor. There are those who believe that ninety-eight per cent. of their employees would not even consider the question.

Reward for length of service is no new idea, no experiment; there are many examples in other fields to be had to prove its worth and practical application. Why have the great majority of employers of power-plant en-

gineers seemingly ignored its means to gain added loyalty and length of service?

The comparatively few companies now paying pensions are in a measure pioneers in this work, and it is to be hoped that they will make public their method of procedure. If publicity is given this matter, it may be the means of exciting the interest of employers who would adopt a similar plan were they assured of its success.

A Good Day's Work

What constitutes a good day's work for an engineer? How may the superintendent know when a good day's work has been done?

In the small plant the engineer would doubtless feel that he had earned his pay if he did nothing but keep all apparatus in good shape with a minimum of expense. If he does his own firing, he will also attend to the washing out of the boiler and do many small repair jobs which the superintendent knows nothing about.

Because the engineer can be seen sitting in a chair, apparently doing nothing it does not follow that he is not doing a good day's work. His brain may be busy solving a problem that will produce better plant operation.

The superintendent usually takes it for granted that the engineer who is always engaged in manual labor is a more valuable man than the one who appears to be doing nothing.

One man is engaged in routine work, or shoveling fuel into the furnace, the other is engaged in formulating plans to reduce the necessity of shoveling so much fuel. It requires but little thought to determine which man is doing the better day's work.

In larger power plants the oiler travels over more floor area than the chief engineer. Each does a good day's work if they perform their work to the best of their ability. If the chief engineer neglects doing a duty that should receive attention, and the oiler performs his duties to the best of his ability, he is doing a good day's work, and better than his chief.

It is not always so much what is done as how it is done that counts in the long run. A man may occupy half an hour in making a necessary adjustment and not do another thing all day, and yet have done a good day's work. Neglecting to make the adjustment might result in an expensive accident.

Another man may work hard all day, but neglect the one thing requiring attention and by this neglect permit an accident to occur that would amount in damage to more than he receives for a year's work.

A romping bird dog does not compare with a hunting dog, trained to point out the position of the game, nor does a hurly-burly engineer compare with a thinking engineer in doing a good day's work.

Steam-Turbine Engineering

Ten years ago the following statement appeared in an engineering journal in relation to a two thousand-horsepower turbo-generator: "This was the first American plant where steam-turbine units of large size were installed."

One can scarcely realize that a two thousand-horsepower turbine was ever considered a large unit when compared with the latest development in turbine practice. But ten years ago it is doubtful if even the dreamer of future triumphs had a glimmer of the proportion to which the turbine was to grow. And the end is not in sight for no one seems willing to predict how large in capacity steam turbines will be built. As someone put it, the limit in size and capacity seems, at present, to be governed by the ability to pay the price of construction.

As the turbine has increased in size and capacity the condenser problem has been augmented. One naturally associates a surface condenser with the regulation cast-iron casing. When it comes to making a condenser, capable of handling the steam exhausting from a twenty-five thousand or thirty thousand steam turbine, the size of the unit demands a structure of greater strength than is afforded by cast iron, under ordinary operating conditions. A combination of steel and cast-iron condenser body with water heads has been found advisable in one instance of large-turbine practice.

A condenser capable of condensing the steam from a twenty-five thousand-kilowatt turbine would be equipped with a circulating pump of about forty-two thousand gallons capacity per minute. In fact, the condenser outfit for a large unit would require as much attention, while running, as is given by many engineers to their entire equipment.

With the coming of large turbines the field of the operating engineer has broadened. Ten years ago the engineer in charge of a two thousand-horsepower turbine was considered among the upper class. Today he would be considered of minor importance as a turbine operator. The larger units require men who understand their business. A mistake in operating a small unit means but a comparatively small monetary loss: with one of the monster turbines it may mean a large outlay in repairs beside the loss of output.

The two thousand-horsepower turbine has sunk into insignificance. How long will it be before the thirty-five thousand-kilowatt unit will be regarded as a past mile stone in the march of progress?

It is said that the Pennsylvania R.R. will electrify through to Elizabeth, N. J. This is a step toward the electrification of the entire New York division, and an indication of a general tendency which means more power plants and more chance for the big power-plant engineer.

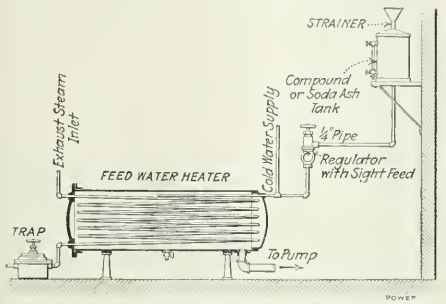
The accidental opening of a valve controlling the flow of water under a head of 450 ft. through a penstock to turbines in the 12,000-hp. Pioneer station of the Utah Light & Railway Co., wrecked the entire plant. While seldom so serious, the mistakes of opening or closing wrong valves, or the right valves at the wrong time are all too common in power plants. It pays to make it a habit to think what the consequences are likely to be before operating a valve.

The American Society of Mechanical Engineers has doubled in membership in the last eight years. So said Secretary Calvin W. Rice at the recent local meeting of the society in New Haven. We predict that it will more than double in half that time if a few more sections of the country take up these local meetings as have Boston, New Haven and Philadelphia, and show a corresponding enthusiasm to that which has been evident in the meetings in the above cities in the last two years.

READERS WITH SOMETHING TO SAY

Soda-Ash for Boiler Waters

The recent article by Mr. Bromley and discussions on the subject of soda-ash calls to my mind a plant that has been using soda-ash for some time with good results. The water is taken from the city mains, and the scale resulting from its use is composed principally of carbonates and sulphates of calcium. All the exhaust drips are returned to the heater through an efficient separator which removes the oil which formerly went through a skimming tank, and, consequently, a great deal of oil went into the boilers. Several kinds of compounds were used which did more damage to the handhole gaskets than it did good to the scale or oil. After the separators were put in very little oil went into the boilers, and soda-ash was substituted for compound with good results.



Piping for Heater and Soda-Ash Tank

This is used at the rate of about 1 lb. per 24 hr. per 40 to 50 boiler horsepower, whereas Mr. Bromley recommends about 8 lb. per 100 boiler horsepower or four times as much.* There are no two plants that will require the same treatment, and, for that reason I believe that the conclusions reached by Mr. Bromley might be misleading unless the existing conditions are very carefully studied as well as a chemical analysis of the water made. When it was decided to use soda-ash in the above mentioned plant the matter was figured out along the same line as Mr. Bromley calculated, but after using the soda-ash at that rate for a few weeks it was found that many of the tube caps gaskets were leaking. In fact, the soda-ash oozed out through them and hung like huge icicles on the tube caps. Also it was necessary to increase the amount of cylinder oil used. The compound or soda-ash did not seem to affect the gaskets in the steam line, to any extent, but after the compound had been used several months several leaks showed up in the pipe threads of the flanges and fittings. The manner in which the soda-ash and compound were fed into the boilers is shown in the accompanying sketch, and is so simple that it needs little explanation. The soda-ash is dissolved (the amount required for one day) in about 3 or 4 gal. of hot water and poured into the feeder tank, then the feed valve is set to feed a very small stream into the water entering the feed-water heater. This will feed the chemicals to all boilers in proportion to their rate of working, and will be fed in about 6 to 8 hr. If a greater quantity of water was used it could be made to cover a longer period, but when set to feed by drops it would clog up with sediment.

I believe that the proper amount to use can be better determined by trial than by calculation. If too much is used it will cause foaming, and affect the lubrication of the engines.

J. C. Hawkins.

Hyattsville, Md.

*[The author of the article referred to stated that 8 lb. of soda-ash would be required as an initial charge to bring the water (5000 lb. for a 100 hp. boiler) up to 3 per cent. (over) normal solution, but not that 8 lb. should be put in daily. To quote from the article: "Unless the boiler primes or there are water leaks or the blowoff is used frequently, little soda ash will be lost from the boiler, and the solution will remain at the proper concentration."—Editor.]

16-Lb. per Hp-Hr. Noncondensing

Asa P. Hyde in a letter published in the Sept. 23 issue of Power criticizes a test on an 19x24-in. Lentz simple engine, conducted by F. W. Dean, of Boston, expressing his doubts in regard to the correctness of the results obtained. Mr. Hyde bases his reasons on the following statements which were published in the original article on the test which was an extract from Mr. Dean's report to the Erie City Iron Works:

First, steam was so perfectly condensed that only a trifling quantity of vapor escaped, so small that it would not affect the result by a measureable quantity.

Second, the reducing motion was practically correct.

Third, current was absorbed by a water rheostat.

In regard to the first statement it may be said that the intensity of absorption of moisture by the atmosphere depends on the time and the surface exposed to the surrounding atmosphere. The condensed steam was weighed during the test in barrels about 24 in. in diameter, containing approximately 400 lb., and each barrel was filled in about 4½ min. On account of the small opening of the barrels, and the short time it took to fill them, it is out of the question that a quantity could be absorbed by the atmosphere which would have an appreciable bearing on the result. Furthermore, the water was intentionally kept at a comparatively low temperature, about 165 deg., to keep the water in the barrels considerably below the steam temperature.

In regard to the second statement, it can be asserted that there hardly exists a reducing motion that is "absolutely" correct. That is the reason why in the report the word "practically" was used. The reducing motion was carefully examined before the test, and found so nearly correct that it was considered that the stretching of the indicator cord would produce a greater error than the slight fault in the reducing motion. Though the latter could not be termed "absolutely" correct, the error was so slight that it was not measureable.

The latter consisted of a heavy beam to which the sufficient positive and negative electrodes were attached. There were eight pairs of electrodes altogether. These were immerged in the water of eight separate barrels. The amperage could be decreased or increased by raising or lowering the electrodes. A man was stationed right at the barrels in direct communication with the man in charge of the test, and at the direction of the latter, the electrodes were held immerged in the water to such extent as to keep the amperage absolutely constant. The voltage was kept constant by means of a field rheostat which was under the direct supervision of the consulting engineer in charge of the test. All the instruments were carefully calibrated to make sure of their accuracy.

It is plain from the above statements that everything had been done to get accurate figures of the steam consumption of the engine. It can be asserted that conditions were favorable for obtaining correct results, as the steam pressure, superheat and load were practically constant during the test. The fact that the water barrels for weighing the condensed steam were filled up at exactly the same intervals, also emphasizes the correctness of the steam consumption obtained during the test.

Professor Moyer, of the State College of Pennsylvania, was recently in charge of a test on the engine used during the Dean test. The object of this second test was to determine the steam consumption of the engine with higher superheat than was obtainable during the first test. The data on this test will be published shortly in POWER, but at this date it may be stated that with approximately 150 lb. pressure and 150 deg. superheat, a steam consumption of close to 15 lb. per i.hp.-hr. was obtained. This test tends to corroborate the figures obtained by Mr. Dean.

S. ROSENZWEIG,
Erie City Iron Works.

Erie, Penn.

Diagrams from an Old Engine

The accompanying diagrams were recently taken from an old beam engine which has been in regular service for about 70 years, during which time the most extensive al-

FIG. 1. H.-P. DIAGRAMS FROM AN OLD ENGINE

teration or repair consisted of fitting a smaller high-pressure cylinder which was done many years ago. The high-pressure cylinder is 25½ in. diameter by 33 in. stroke and the low-pressure is 33 in. diameter by 66 in. stroke. The boiler pressure is 80 lb., and the diagrams show 75 lb. initial and about 24 in. vacuum.

From all that can be learned concerning this engine the cylinders have never been rebored, although one or two lots of rings have been fitted. Both the beam and connecting-rod are of cast iron, the latter being about

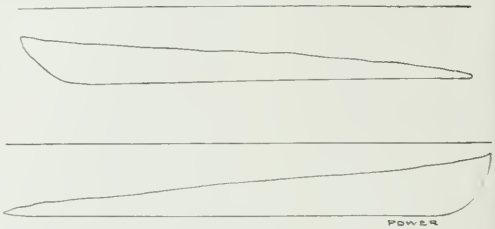


FIG. 2. L.-P. DIAGRAMS FROM AN OLD ENGINE

17-ft. centers. The low-pressure cylinder is fitted with piston valves and the high pressure with a quick-acting flat valve.

It is to be observed that the diagrams from the high-pressure cylinder show very fair expansion curves, the form of the diagrams indicating that this old engine is probably quite as economical as many modern engines with the latest types of valve-gears.

E. R. PEARCE.

Rochdale, England.

Clear Water from a Muddy River

It would be useless for the writer to deny the logic or conclusions of A. P. Connor in his especially interesting and valuable article on the above subject, appearing on pages 611 and 612 of the Oct. 28 issue of POWER, but it appears that another cause may be the actual agent in making the above phenomenon possible, and this phenomenon fully complies with the conditions referred to. In regard to the conditions, it may be said that the explicit manner in which they have been set forth enables this writer to go fully into the phases which would tend to bring about the results described in the original article, and which are based on different reasons.

It is a fact that artesian water or flowing wells are common in the region of the lower Potomac at a depth of 30 or 50 ft. below the river level. Assuming that the river referred to is the Potomac, on account of the address being given as Washington, it is my opinion that the crevice in the rock bottom of the river is of sufficient depth (approximately 90 ft.) to be supplied by the same strata of artesian water which is found farther down stream at, say, 50 ft., allowing for the fall in the river. Our geological friends tell us that subterranean rivers are not the source of our artesian water, but rather a percolating process through the rock. Now, Mr. Connor says the water is of a lower temperature than the river water proper; therefore it would settle to the bottom of the crevice, in which case it would carry the sediment with it and would have filled the space long ago. The fact that the crevice is clear and that even rapid pumping does not create a down flow and carry turbid water to the pump suction convinces me that there is an upward flow of

artesian water at this point. This is only in the nature of a supplement to Mr. Connor's article and, I believe, adds interest, geological as well as engineering.

LEON LEWIS.

Washington, N. J.

Mr. Connor's reasons for the presence of clear water in a crevice at the bottom of a muddy river, as expressed in the Oct. 28 issue, do not agree with my theory of the situation. From conditions described in his article it appears that the source of clear water is from a spring in the bed of the river. He states the temperature is approximately 50 deg. F., and varies but little throughout the year.

He also states that in winter the warmer water would be in the crevice at the bottom of the river while the freezing water and ice were on top, and also that the temperature at the bottom of the hole would be about 48 deg. F. in winter.

When water in rivers or lakes gets colder than 39.1 deg. F., which is its temperature of greatest density, it "turns over," that is, the water on the bottom comes to the top and the water on top goes to the bottom. We see from his statement that if the water in the crevice at the bottom of the river was river water its temperature would be 39 deg. F. instead of 48 deg. F., as stated by Mr. Connor.

If the water in the hole was clarified from the river water its temperature would be practically the same on top as on the bottom, for in river waters there are small currents and also the current of the stream which keep the water agitated and the suspended matter in suspension. These small currents are what causes needle and anchor ice to float at all depths in rivers and lakes.

Mr. Connor states that the suspended matter is of a clayey nature. For such substance to settle requires that the water be quiet, and also requires considerable time. As the suspended matter settles to the bottom, what would keep it from entering the strainer and suction pipe? If the water in the hole is in a quiet state, what would prevent the hole from filling up with the sediment from the water. I am of the opinion that the clear water in the hole is from a spring, as the water from springs varies little in temperature throughout the year.

One sure way of telling if the water in the hole is from the river would be to have the waters from the river and hole analyzed. If the analysis is the same for both samples, most likely the water in the hole has its source from the river, but if different it must come from some other source.

LAWRENCE KJERULFF.

Kansas City, Mo.

On page 611 of Oct. 28 issue, A. P. Connor tells how supply of clear water was obtained from a muddy river. While the facts as given in this instance are truly interesting, it would seem wise to investigate thoroughly before attempting to duplicate these conditions by artificial methods as Mr. Connor suggests might be done.

All running streams deposit more or less solid substance in the low places in their beds, tending to even up the surface over which they flow and had there not been some special reason for the existance of this hole in the river bed no doubt nature would have filled it ages ago. It seems probable that an underground stream finds its way into the bottom of this pit; therefore the flow being upward there is no chance for the muddy water to get into the hole. This would also account for the uniform low temperature of the water.

LEON ROUNDY.

Concord Junction, Mass.

[In connection with Mr. Connor's article and the above discussion of it, it is interesting to read the excerpts below from the Washington *Star* for Nov. 4, 1913.

Why there are no artesian wells in Washington and why some are found as near as Colonial Beach and at other points down the coast is explained in some detail by Olaf A. Ljungstedt, of the Geological Survey. Mr. Ljungstedt takes exception to an article in the "Star" some time ago purporting to explain the geology of the artesian wells south of Washington. The story he refers to made the following statement:

To illustrate how slowly the water travels: Many artesian or flowing wells are found along the Potomac River at Colonial Beach and other points in Virginia, about sixty miles from Washington. This water is obtained by drilling into a sandstone formation which extends along the Potomac valley and into Maryland and outcrops near Frederick, Md., some fifty miles north of Washington. It takes about 100 years for the water of this subterranean river to flow that distance, that is, the rains falling upon the exposed portions of the porous rocks near Frederick sink in and move southward at the rate of about one mile a year.

NO WATER COULD FLOW

Mr. Ljungstedt says that this statement would be interesting if true, but that there is no truth in it. Between Frederick and Washington there is a deep wall of impervious rock, through which no water could flow in a million years. This cuts off Washington and the region to the south from the benefit of any artesian flow from the accumulation of rainwater in the Frederick region. But between that point and the flowing wells at Colonial Beach there is another deposit of pervious rock through which the water can seep, so that the supply for the flowing wells at the beach is of comparatively local origin.

Assuming that the location of the crevice mentioned by Mr. Connor is in the Potomac River and in Washington, it would appear from Mr. Ljungstedt's comment that either the water taken from the crevice is water that seeps in from areas local to the crevice or is river water.—EDITOR.]

Method of Cost Finding

In the Oct. 21 issue, Mr. Milton asks for the method of obtaining the cost per kilowatt-hour of generating electricity in a 200-kw. plant, and gives the cost of labor per day and coal per ton.

This information is too meager to obtain more than a rough approximation of the probable cost of power in this particular plant. The following is the general method employed in determining the cost of power. With this and the information which Mr. Milton presumably has, he should be able to compute very closely the cost for his plant.

The cost of operating power plants is divided into two parts:

(1) Fixed charges.

(2) Operating costs.

Fixed charges cover all expenses that do not vary with the output of the plant. In the average case these consist of interest on the investment required for the plant, depreciation, taxes and insurance.

Interest varies with the nature of the security. Unless definite figures are available, 5 per cent. of the capital invested may be taken as an average figure.

Depreciation represents the amount necessary to be set aside each year at compound interest to replace the plant by the time it has either become worn out or uneconomi-

cal for further operation. General practice shows that the latter cause is usually the one regulating the life of the plant. In most cases 5 per cent. represents a fair charge for depreciation. This is on the basis of a useful life of 14 years and interest at 5 per cent.

Taxes vary with the locality but may be taken at 1 per cent. of the value of the investment if actual figures are not available. The cost of insurance will be about one-half of 1 per cent.

Operating costs may be divided as follows:

Labor.
Fuel and water.
Oil, waste and supplies.
Ash removal.
Repairs and maintenance.

The cost of labor varies so much with the locality and type of plant that this item can be determined only after the exact conditions are known. In New York City firemen can be obtained for about $60 per month, assistant engineers at $80 to $100 and chief engineers at $100 to $125 per month.

The cost of fuel and water is largely affected by local conditions. Also the amount required will depend, to a great extent, on the design of the plant and the economy of the apparatus used. If economical apparatus is installed the first cost and fixed charges will be high and the coal and water charges low, while if an uneconomical plant is installed the reverse will be the case. Obviously the best plant is one in which the sum of these two items is the least. For an average plant of the size under consideration the coal consumption would be about 8 lb. per kw.-hr.

Oil, waste and supplies will approximate from 5 to 10 per cent. of the total operating expenses. For a plant of 200 kw. capacity this item will amount to about $500 per year.

Ash removal may or may not be an item in the operating costs and no predetermined amount can be given unless local conditions are known.

Repairs and maintenance depend to a great extent on the quality of the material and apparatus installed in the plant, and the efficiency of the operating force. Where first-class material and apparatus have been used and a good grade of labor employed it may be taken at about 2 per cent. of the first cost of the plant.

The total cost for generating power depends largely upon the load factor. With a good load factor a plant of this size should be able to generate electricity at a total cost of 3¼ to 3½c. per kw.-hr.

If steam is supplied by the plant for heating, this should be deducted from the total charges as computed above. If the amount of radiation is known the amount of coal required to generate this steam will be about 15 lb. per sq.ft. for a heating season in the vicinity of New York City which is 200 days with an average temperature of 35 to 40 deg. F. For other localities this amount will vary directly with the length of the season and the severity of the climate.

The above estimate is for electricity delivered at the switchboard. In the case of a central station the cost of distribution and lamp renewals must be taken into consideration.

W. L. DURAND.

Brooklyn, N. Y.

Referring to Mr. Milton's request in POWER of Oct. 21 issue relative to cost of power per kilowatt-hour, the following is submitted. We are to consider a 200-kw. direct-connected plant.

The generator manufacturers will guarantee a mechanical efficiency of 91 per cent. for a generator of the above capacity while the manufacturers of a high-grade engine will safely guarantee 90 per cent. mechanical efficiency. Considering the engine and generator as a direct-connected unit, it will have an overall efficiency of 81.9 per cent.; 200 divided by 0.819 gives 245, which shows the work done by the steam engine; 245 divided by 0.746 will, therefore, give the indicated horsepower of the engine, which is 328.

Assuming the engine of this horsepower to be of the compound type we can assume a steam consumption of 23 lb. per horsepower per hour for an engine running noncondensing, since the exhaust steam is to be used at times for steam heating. The steam consumption will, therefore, be

$$328 \times 23 = 7550 \text{ lb. per hr.}$$

A good boiler will evaporate 9 lb. of water per lb. of coal, so that

$$\frac{7550 \times 24}{9 \times 2240} = 9$$

tons of coal will be required every 24 hr. At $4.50 per ton the coal bill will amount to $40.50. Wages for 24 hr. are stated as $10. To these should be added $0.25 to cover supplies, oil, etc., making a total cost of $50.75 for 24 hr. operation. Therefore,

$$\frac{50.75}{200 \times 24} = 1.06$$

or a trifle over 1c. is the cost of manufacturing a kilowatt-hour. It must be remembered that the above does not take into account repairs, interest, taxes, insurance, depreciation of machinery or cost of feed water which are at times important factors to be considered. Also the exhaust steam may not be used for heating so that the engine can be run partly condensing which will decrease the cost of operation. The values assumed may have to be changed to meet the guarantees of the generator, engine or boiler manufacturer, which will change the final result accordingly. The values assumed are fairly safe and the method is general.

Holyoke, Mass. DAVID FLIEGELMAN.

Jacketing of Cylinders

The writer has recently noticed the difference between steam-jacketed locomobile cylinders and flue-gas-jacketed cylinders, observing that, after short service, the flue-gas jacketing imparts a coat of soot which is one of the best heat nonconducting materials. Perhaps many readers of POWER have proved this by getting the bottom of an ordinary kettle covered with soot when it was boiling and then held it on the tips of their fingers, of course being very careful not to break the film of soot, and the question arises as to how much actual benefit is derived by the cylinder from the flue gas after it once becomes coated with soot. It looks as though soot should be very efficient jacketing and a good nonconductor of heat, and I would like to know if any readers of POWER have used it successfully as a covering for pipes or cylinders.

Rochdale, England. E. R. PEARCE.

INQUIRIES OF GENERAL INTEREST

Nonreturn Valve—On what principle does a nonreturn valve k?

E. P.

On the principle of a balanced check valve.

Tobin Bronze—What is Tobin bronze?

A. S.

Tobin bronze is an alloy composed of copper, 61.2 per ; zinc, 37.14 per cent.; tin, 0.9 per cent.; iron, 0.18 per ., and lead, 0.38 per cent.

Diversity Factor—What is meant by the term diversity or?

A. D. B.

t is the ratio of the sum of the individual maximum de- ds of the distribution system (which may occur at differ- times) to the greatest demand on the generating system, ng a given period.

Exhaust Noise—What causes the popping sound when a gas steam engine exhausts into the atmosphere?

J. W. D.

The sudden disturbance of the atmosphere, just as when surface of still water is struck with a lath producing den displacement of air which is extended through the osphere as a sound vibration.

Boiler Riveting—In the riveting of boiler seams which is better, zigzag or chain riveting?

J. L.

Zigzag riveting has the advantages over chain riveting it requires less lap of the sheets at the joint; that it dis- utes the strain on the sheets more uniformly along the t and that it affords better support for calking.

Engine Speeds—Why cannot a Corliss engine be oper- l at as high a speed as a slide-valve engine?

J. P.

The speed at which a slide-valve engine can be driven imited only by the pressure of the steam and the strength he parts of the engine. The speed of a Corliss engine is ited by the speed at which the valve release gearing l operate.

Rust Joint Compound—What is a good formula for a com- nd for making rust joints?

F. W. D.

The old English formula for rust joint cement was 200 of wrought-iron chips to 2 lb. sal ammoniac and 1 lb. of r of sulphur. This will set in 24 hr. For quicker setting y about 50 lb. of wrought-iron chips should be used in ce of 200 lb.

Erratic Safety Valve—What can cause a safety valve that ins to blow at 100 lb. to continue to blow until the pres- e has fallen to 90 lb.?

E. P.

The valve is either held open by friction of the working ts, or else the mechanism is of such a kind or condition t the higher pressure throws the valve out of line prevent- its becoming reseated.

Water Hammer—What is "water hammer"?

E. P.

When steam in one part of a system of connected pipes or sels condenses more rapidly than in another part, a vacuum reduction in pressure is formed and steam, rushing into space, carries along any water in its path, causing the er to be driven at high velocity against the sides of the or vessel producing what is called "water hammer."

Cotton Cable Dressing—Is there any treatment which will then the life of cotton cables? We want something that l reduce the wear without causing them to slip.

C. B.

good dressing for drive rope consists of a mixture of s, any vegetable oil and powdered graphite thoroughly ground and mixed, warm. The proper proportions will vary with conditions, climate, etc., but a good average proportion is the following, the parts being by volume: 1 of rosin, 4 of graphite and 8 of oil.

Filling a Lubricator—What is the right procedure when filling a lubricator?

E. P.

To refill a lubricator close the water-feed valve and the regulating valve, and open the drain valve; then remove the filler plug. When the water has all drained out of the oil reservoir close the drain valve, fill the oil reservoir with oil and replace the filler plug. Then to operate the lubricator, open the water-feed valve and adjust the regulating valve to the desired rate of feed.

Compression and Temperature—What effect does the compression of steam in an engine cylinder have on its temperature?

J. H. W.

Pressure increases as volume decreases, and the pressure at any particular point will be practically inversely as the volume. The temperature of the steam at any pressure of the compression will be at least as high as the temperature of dry saturated steam at the same pressure in a boiler and the temperature may rise even higher. When dry saturated steam is compressed without transfer of heat to the piston or cylinder it becomes superheated.

High Compression—Is it possible for steam to be compressed in an engine cylinder to higher than initial pressure? If so, what happens?

J. H. W.

If the exhaust valve closes so early in the return stroke of the piston as to imprison a large volume of exhaust steam, the amount of compression may be sufficient to raise the pressure at the end of the stroke even higher than the boiler pressure and it may stay higher until the steam valve has opened or is forced off its seat. When either happens the compressed steam discharges back into the steam chest until its pressure is reduced to the live-steam pressure in the steam chest, or in common parlance, "is pumped back into the boiler."

Air-Bound Trap—What causes a steam trap (bucket type) to get airbound? Why will water not flow into a trap filled with air the same as if it were filled with steam?

J. W. D.

A steam trap or steam radiator remains "airbound," preventing the admission of steam, because the air is heavier than the steam. When water is presented to the airbound trap, the air is compressed to the same pressure as the water and the viscosity of the water and its friction resist the gravity of the water to displace the air. Dislodgment of the air is also made more difficult, as is commonly the case in water pipes, when the air is in the form of a foam or aggregation of bubbles held together by the viscosity of their liquid envelopes which are gathered up from a pipe or vessel which has contained dirty water.

Pressure Increases—If a volume of 150 cu.in. of water at a temperature corresponding to that of steam at 100 lb. pressure is introduced into a cubic foot of steam at that pressure, will the pressure be increased or decreased?

J. W. D.

Assuming the steam to be dry and saturated, the effect would be the same as if a space containing the 150 cu.in. of water had the original 1728 cu.in. of steam compressed into it until the combined volume was only 1728 cu.in. This would necessarily result in (a) a rise in temperature and pressure of the steam and then (b) a transference of part of the heat of the steam to the water, accompanied by loss in pressure and temperature of the steam until the water rose to the same temperature as the steam. There being more than the original total heat present in the mixture (the additional heat being the heat introduced to compress the steam into smaller volume) the final temperature and pressure would necessarily be higher than the original temperature and pressure.

ENGINEERS' STUDY COURSE

Trigonometry—II

The *complement* of an angle is that angle which added to the first will make an angle of 90 deg. For example, an angle of 30 deg. is the complement of one of 60 deg.; 45 deg. of 45 deg., and so on.

In the diagram, Fig. 4, angle *IAB* is the complement of angle *BAC*. Just as *BC* is the sine of angle *BAF*, *DB* is the sine of angle *IAB*, but *DB* being equal to *AC* is equal to the cosine of angle *BAF*. This shows that *the cosine of an angle is equal to the sine of its complement and the sine of an angle is equal to the cosine of its complement.*

The same might be shown from Fig. 2 (last lesson) for, the sum of the angles of any triangle being 180 deg.

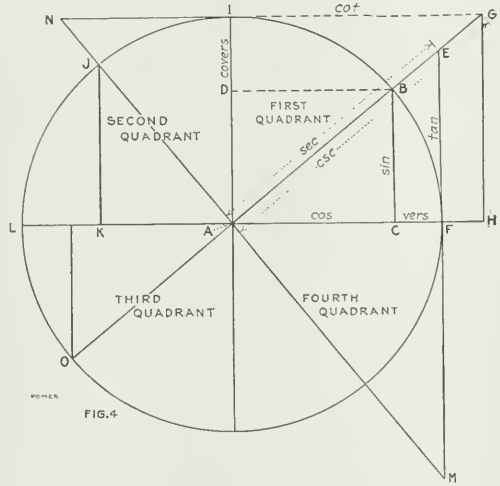


FIG. 4

and the angle *C* a right angle, the sum of the other two angles must be 90 deg.; hence *B* is the complement of *A*.

Just as $sin\ A = \frac{a}{c}$ so also is $sin\ B = \frac{b}{c}$, but $cos\ A = \frac{b}{c}$, hence $cos\ A = sin\ B$.

Similarly in either way it might be proved that *each function of an acute angle is equal to the co-named function of its complementary angle.* In fact, cosine, cotangent, cosecant and coversine are simply abbreviated ways of saying complement's sine, complement's tangent, complement's secant and complement's versine.

It follows from the last rule that *the function of any angle between 45 deg. and 90 deg. is equal to the cofunction of the complementary angle between 0 deg. and 45 deg.* The importance of this is to be observed in connection with the computation of tables of natural functions for it is necessary to carry the tables only as far as 45 deg.

Tables of trigonometrical functions, as they are eall are the values of functions corresponding to angles creasing by degrees or fractions thereof, which have b carefully worked out so that solutions of problems be quickly obtained without the drudgery of calculat the functions. Such tables are available in handbo and books of tables and carried out to far greater s divisions of angles than the abridged table herew (Table 1). The latter, however, will serve to illustr the use of such a table and will do for such problems appear in this course.

TABLE 1. NATURAL FUNCTIONS OF ANGLES

Deg.	Sine	Cosecant	Tangent	Co-tangent	Secant	Cosine	D
0	0.0000	Infinite	0.0000	Infinite	1.0000	1.0000	
1	0.0175	57.2987	0.0175	57.2900	1.0002	0.9998	
2	0.0349	28.6537	0.0349	28.6363	1.0006	0.9994	
3	0.0523	19.1073	0.0524	19.0811	1.0014	0.9986	
4	0.0698	14.3356	0.0699	14.3007	1.0024	0.9976	
5	0.0872	11.4737	0.0875	11.4301	1.0038	0.9962	
6	0.1045	9.5668	0.1051	9.5144	1.0055	0.9945	
7	0.1219	8.2055	0.1228	8.1443	1.0075	0.9925	
8	0.1392	7.1853	0.1405	7.1154	1.0098	0.9903	
9	0.1564	6.3924	0.1584	6.3138	1.0125	0.9877	
10	0.1736	5.7588	0.1763	5.6713	1.0154	0.9848	
11	0.1908	5.2408	0.1944	5.1446	1.0187	0.9816	
12	0.2079	4.8097	0.2126	4.7046	1.0223	0.9781	
13	0.2250	4.4454	0.2309	4.3315	1.0263	0.9744	
14	0.2419	4.1336	0.2493	4.0108	1.0306	0.9703	
15	0.2588	3.8637	0.2679	3.7321	1.0353	0.9659	
16	0.2756	3.6280	0.2867	3.4874	1.0403	0.9613	
17	0.2924	3.4203	0.3057	3.2709	1.0457	0.9563	
18	0.3090	3.2361	0.3249	3.0777	1.0515	0.9511	
19	0.3256	3.0716	0.3443	2.9042	1.0576	0.9455	
20	0.3420	2.9238	0.3640	2.7475	1.0642	0.9397	
21	0.3584	2.7904	0.3839	2.6051	1.0712	0.9336	
22	0.3746	2.6695	0.4040	2.4751	1.0785	0.9272	
23	0.3907	2.5593	0.4245	2.3559	1.0864	0.9205	
24	0.4067	2.4586	0.4452	2.2460	1.0946	0.9135	
25	0.4226	2.3662	0.4663	2.1445	1.1034	0.9063	
26	0.4388	2.2812	0.4877	2.0503	1.1126	0.8988	
27	0.4540	2.2027	0.5095	1.9626	1.1223	0.8910	
28	0.4695	2.1301	0.5317	1.8807	1.1326	0.8829	
29	0.4848	2.0627	0.5543	1.8040	1.1434	0.8746	
30	0.5000	2.0000	0.5774	1.7321	1.1547	0.8660	
31	0.5150	1.9416	0.6009	1.6643	1.1666	0.8572	
32	0.5299	1.8871	0.6249	1.6003	1.1792	0.8480	
33	0.5446	1.8361	0.6494	1.5399	1.1924	0.8387	
34	0.5592	1.7883	0.6745	1.4826	1.2062	0.8290	
35	0.5736	1.7434	0.7002	1.4281	1.2208	0.8192	
36	0.5878	1.7013	0.7265	1.3764	1.2361	0.8090	
37	0.6018	1.6616	0.7536	1.3270	1.2521	0.7986	
38	0.6157	1.6243	0.7813	1.2799	1.2690	0.7880	
39	0.6293	1.5890	0.8098	1.2349	1.2868	0.7771	
40	0.6428	1.5557	0.8391	1.1918	1.3054	0.7660	
41	0.6561	1.5243	0.8693	1.1504	1.3250	0.7547	
42	0.6691	1.4945	0.9004	1.1106	1.3456	0.7431	
43	0.6820	1.4663	0.9325	1.0724	1.3673	0.7314	
44	0.6947	1.4396	0.9657	1.0355	1.3902	0.7193	
45	0.7071	1.4142	1.0000	1.0000	1.4142	0.7071	
Deg.	Cosine	Secant	Co-tangent	Tangent	Cosecant	Sine	D

For functions from 45 deg. to 90 deg. read from bottom of table upward.

In this table the functions versine and coversine omitted because they are very little used. Many ta

also omit the secant and cosecant, the remaining four—sine, cosine, tangent and cotangent—being those most frequently used in calculations.

It is evident how the table is used for finding the functions of any angle up to 45 deg. and based on the explanation just given of the relations between the functions of complementary angles the table from 45 to 90 deg. would be the original table backward, but with the column headings changed to the co-functions. The table, therefore, is used from the bottom up for angles between 45 and 90 deg.

The Four Quadrants

All angles up to 90 deg. are of the first quadrant, as it is called. All angles from 90 to 180 deg. are of the second quadrant, as marked in Fig. 4; all from 180 to 270 deg. are of the third quadrant and all from 270 to 360 deg. of the fourth quadrant.

The sine of an angle extending into the second quadrant as FAJ will be JK which is the same as the sine of the angle JAL. In other words, the sine of any angle, of the second quadrant is the same as the sine of an angle which added to the one in question will equal 180 deg. Such an angle is known as a *supplement* of the first. Similarly it could be shown that all the functions of any angle in the second quadrant are equal to the functions of the supplement of that angle, although certain of them take the negative sign. The tangent of the angle FAJ is FM and is negative. The sine, cosine, tangent and cotangent are negative if the lines that represent them are opposite in direction to the lines that represent the corresponding functions of an angle in the first quadrant. The secant and cosecant are negative if they are opposite in direction to the moving radius. The *moving radius* is the other line of any angle as distinguished from the *fixed radius* AF.

Continuing now to analyze the signs of the other functions of the angle FAJ, the cosine is AK and, according to the above definition, negative; the cotangent is IN, also negative; the secant is AM and negative, and the cosecant is AN and positive.

Similarly the third and fourth quadrants could be investigated, but angles of these quadrants (angles greater than 180 deg. and known as *reflex angles*) are seldom used. It is sufficient to give the following as ways to determine, for any angle what lines represent the functions and whether they are positive or negative.

For any angle the lines representing the functions are:

For the sine, a line from the end of the moving radius perpendicular to the horizontal axis.

For the cosine that part of the horizontal axis intercepted between the center of the circle and the foot of the sine.

For the tangent the line perpendicular to, and from the extremity of, the fixed radius to the moving radius produced (or extended).

For the cotangent the line perpendicular to, and from the end of, the vertical radius dividing the first and second quadrant, to the moving radius produced.

For the secant, the line from the center of the circle along the moving radius produced to the tangent.

For the cosecant, the line from the center along the moving radius produced to the cotangent.

For angles of the various quadrants the signs of the functions are:

TABLE II

	1st Quad	2nd Quad	3rd Quad	4th Quad
Sine and cosecant	+	+	−	−
Cosine and secant	+	−	−	+
Tangent and cotangent	+	−	+	−

All angles of the first quadrant, i.e., all angles between 0 and 90 deg., are more commonly known as *acute angles*, and all angles of the second quadrant, i.e., angles greater than 90 deg. and less than 180 deg., as *obtuse angles*. Angles of 90 deg. are *right angles*, of 180 deg. *straight angles* and all angles larger than 180 deg., as before mentioned, are *reflex angles*.

How to find the functions for acute angles from Table I has already been explained. To find the functions of any obtuse angle subtract the number of degrees in the angle from 180 deg., and in the table find the functions of the supplementary acute angle, whose number of degrees is the difference. The signs of the functions may then be found from Table II.

Example: To find the cotangent of 120 deg.

$$180 - 120 = 60 \text{ deg.}$$

From Table I the cotangent of 60 deg. is found to be 0.5774 and, as shown in Table II, an angle in the second quadrant takes the negative sign, for the cotangent, hence

$$Cot\ 120\ deg. = -0.5774$$

Study Questions

6. Having found the functions as called for in the first question (last lesson), find the angle A in degrees from the table.

7. What angle does the guy wire of a steel stack make with the ground if the wire is 100 ft. long and is fastened to the stack 60 ft. from the ground?

8. If the a side of a triangle (Fig. 2, Lesson I) is equal to twice the b side, what is the angle A in degrees?

9. If the angle A is equal to 30 deg., and the side c is equal to 1, what are the other sides of the right triangle?

10. Prove that the sum of the angles of a right triangle is 180 deg.

Last Lesson's Answers

1. $Sin\ A = \frac{3}{5} = 0.6$, $cos\ A = \frac{4}{5} = 0.8$, $tan\ A = \frac{3}{4} = 0.75$, $cot\ A = \frac{4}{3} = 1.3333$, $sec\ A = \frac{5}{4} = 1.25$, $csc\ A = \frac{5}{3} = 1.6666$.

2. $c = \sqrt{a^2 + b^2} = \sqrt{24^2 \times 143^2} = 145$

$Sin\ A = \frac{24}{145} = 0.1655$ = also $cos\ B$

because the side adjacent to the angle B is opposite the angle A (see the definitions of the sine and cosine at the top of the second column on page 766).

3. The tangent of the angle or $\frac{a}{b} = 0.8$. Then, if $b = 160$ ft., $a = 160 \times 0.8 = 128$ ft.

4. $Sin\ A = \frac{a}{c} = 0.6$, $cos\ A = \frac{b}{c} = 0.8$. If $c = 240$ ft., then $\frac{a}{c} = \frac{a}{240} = 0.6$, $a = 144$ ft. and $\frac{b}{c} = \frac{b}{240} = 0.8$, $b = 192$ ft.

5. The cosine being equal to the sine of the complement, $cos\ 2A = sin\ (90 - 2A)$ but $sin\ A = cos\ 2A$, then $sin\ A = sin\ (90 - 2A)$ and $A = 90 - 2A$, $3A = 90$ or $A = 30$ deg.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Down in Waycross, Ga., they snatched an editor from his sanctum and set him to guiding the destinies of an electric railway. Good for you, Mr. Rhoads, we always knew that some day one of us scribes would make a hit with the public. As Mr. Rhoads was once a motorman early in his career, this may not be his first hit.

⁂

One Mellen, formerly in the New Haven road's employ, predicts that ultimately all railroads will be owned by the government. Some of the roads will be right glad to sell now—and get their money back.

⁂

Accompanied by a man equipped with repair apparatus, an aviator will henceforth patrol a Western power company's lines looking for breakdowns. He will make two trips a week. Whadcha know about that!

⁂

Does Thomas Lipton really believe that he can win the America Cup? He's challenged again. Suggest his next yacht be named "Oolong," or "Suchow," or "Ceylon." This would fiT The case To a "T." Another cup, Gertie, with a little less sugar, please.

⁂

Are we to have a world city? Our state department has directed the diplomats abroad to help boost a $100,000,000-world city, plans for which have been designed by an American sculptor living in Rome. Possible sites suggested are the Jersey coast, The Hague, Rome, Paris, etc. Every nation is to coöperate, but which will get it?

⁂

Ought to do better than this: Philadelphia folks have named a new organization for bringing together the bosses and the educators, The Industrial and Technical Education Congress of the Public Education Association. Think of trying to put "T. I. T. E. C. P. E. A." on one badge, for, of course, they'll have a badge?

⁂

Wanted, a lady policeman and a male stenographer for Chicago; this is according to that city's civil servicers. There is no insistence that the copperess shall don those bifercated things that chiefly distinguish the male, or that the male stenographer cannot carry his hanky in his cuff or wear a wrist watch. Personally, we hope the lady's first arrest will be that stenographer.

⁂

"Did ye iver have a bad fall, Doran?"

"I did, Horan, I've fell from th' state of grace, I've fell full often fer th' loikes of yez, an' oncet I fell off a forty-foot ladder, an'—"

"An' were ye hurted, Doran?"

"No thanks be! I had th' luck to fall off th' first rung an' land on me two feet."

(And then they clinched!)

⁂

Flow of Steam in Pipes*

By A. E. Berggren

The size of piping for the transmission of high-pressure steam has come to be of special economic importance to the consulting engineer in the design of steam plants, as he must not allow too great a drop in pressure with pipes too small to carry the load nor must he allow sizes larger than necessary and thereby increase excessively the first cost of the installation. Many tests of piping, both in laboratories and in actual installations, often of special construction, have been made, and valuable data and formulas proposed for the flow of steam through pipes of standard dimensions, but existing data on tests of long pipes are hard to find.

During the summer of 1911 a series of runs was made on the 2400-ft. line of 3-in. pipe carrying high-pressure steam from the Capitol Heating and Power Station to the State Capitol in Madison, Wis. This is one of several in the tunnel connecting the station and the capitol, and all the curves are easy bends of long radius, so that the pipe may be regarded as straight as far as pressure losses are concerned. It is of standard dimensions with screwed, smooth-face, flanged couplings, anchored about every 150 ft., with slip expansion joints of special design at each anchor station. Throughout its length the pipe is covered with 2¼ in. of 85 per cent. magnesia, with molded forms for the flanged couplings. There is a difference in elevation of 76 ft. in the length of the pipe, drainage being toward the station. Ordinary tilt traps are employed with connection to drain pockets on the under side of the special anchor tees and discharging into a separate 2½-in. return main to the sump.

The series of runs was made up of two condensation or no-load runs, in which no steam was delivered, and records only of pressures and condensation were made; and of six proportional loads up to the limit of the 1-in. take-off pipe at the upper end, which was connected to a surface condenser.

The generally accepted formula of Babcock:

$$W = K \sqrt{\frac{y P d^6}{L (d + 3.6)}} \qquad (1)$$

where

W = Pounds of steam delivered per minute;
P = Drop in pressure in pounds per square inch;
y = Density of steam at mean absolute pressure;
d = Diameter of pipe in inches;
L = Length in feet;
K = Constant depending on friction;

was checked and for the particular conditions under test was simplified to the following:

$$W = 15 \sqrt[1.6]{y P} \qquad (2)$$

This form was found to apply for all loads within reasonable limits, excluding very light and extremely heavy loads, and within the range of pressure drop of 1 to 4 lb. per hundred feet of pipe as allowed in current practice.

To apply to other diameters and lengths of pipe, that part of equation (1) must be included which is a function of the diameter and length. The modified formula for the steam delivered, as derived from these experiments, would be

$$W = 70 \sqrt[1.6]{y P} \sqrt{\frac{d^6}{L (d + 3.6)}}$$

This modified formula gives the weight of commercially dry steam delivered from a drained pipe, where any condensation due to radiation is taken out at intervals. Babcock's formula gave the correct value, as determined in actual experiment, for one load where the drop in pressure was little over three-quarters of a pound per 100 ft., but gave values increasingly large as the loads decreased, and values decreasingly small as the actual load increased above that corresponding to this drop. It should be noted also that in the modified formula, the coefficient remains constant throughout the ordinary change of load, the weight of delivered steam, or the diameter to be calculated, being dependent on the values of density and pressure drop.

*From an article in the "Wisconsin Engineer."

Changing from Oil Fuel to Coal

By F. V. Hetzel*

SYNOPSIS—Different methods of handling coal and ash for large and small plants with suggestions for existing installations.

With the rise in the price of fuel oil, many power houses in the Southwest are facing the problem of burning coal instead of oil. Heretofore these power houses favorably situated near the oil fields of Texas and Oklahoma have obtained their oil at low cost, but oil prices have been going up so steadily that many managers have come to the conclusion that it will pay them to make the alterations in their boiler houses which a change in fuel will make necessary. Boiler settings must be altered, flues and stacks made larger, and provision made for storing and handling coal and ashes. After the simplicity of piping oil to the boiler furnaces, taking care of coal and getting rid of ashes is a disagreeable necessity, but with the wide-spread use of conveying machinery, coal- and ash-handling equipments for boiler houses have been brought to a state of refinement, and managers who are facing this problem will find that such apparatus can be adapted to any conditions of site, or size of boiler house, or amount of storage.

Assuming that there is a railroad siding at the plant, it will be found advisable in most cases to put in a track hopper with a conveyor or an elevator, rather than build a trestle, and dump cars on it. If a trestle dump is used, the coal is spread over a considerable length, and the fireman has to do more wheeling and shoveling to get his coal. Moreover, the first cost of a trestle, and the expensive maintenance of a wood trestle, generally offset what may appear at first as desirable simplicity.

For a hand-fired boiler plant, it is often convenient to store coal just outside the wall of the house, and let the coal flow through holes in the wall to within reach of the fireman. This may suit existing plants when there is no room for overhead storage. In such cases a bulkhead is built parallel to the wall of the house, and the intervening space filled by a chute from the head of an elevator, Fig. 1, or from a conveyor, Fig. 2, or by means of a combination of elevator and conveyor, Fig. 3. The machinery for such a plant is simple and cheap, and the cost of unloading from cars and delivering to bins need not exceed 2c. a ton. For every 100 tons of coal burned, there does not usually result more than 10 tons of ashes. For a small house, it does not pay to install a separate conveyor to gather ashes from in front of the boilers. A wheelbarrow or a hand cart is usually best. An ash elevator and a storage bin are often used, Fig. 5, in such plants; the ashes are stored at a height to flow by gravity into cars or carts, and as they are handled but once, there is no need for the extra labor of loading, as is the case where ashes are piled on a dump until the time comes to take them away.

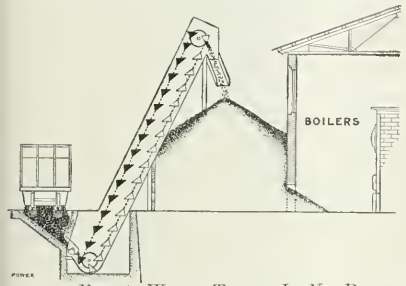


Fig. 1. When There Is No Room for Overhead Storage

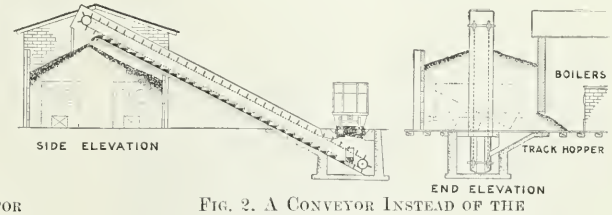


Fig. 2. A Conveyor Instead of the Elevator of Fig. 1

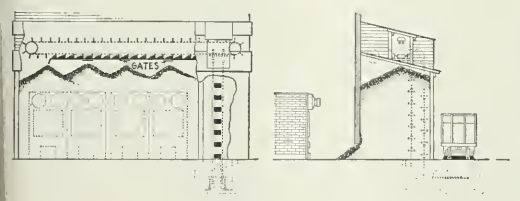


Fig. 3. A Combination Elevator and Conveyor

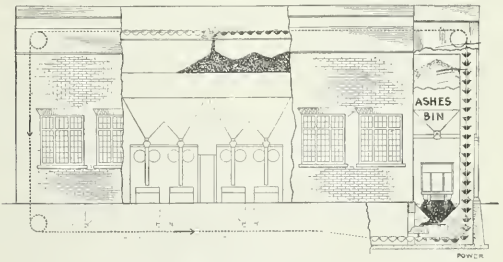


Fig. 4. Typical Installation of Pivoted Bucket Carrier

Since one man cannot fire more than 500 hp. of boilers, under normal conditions, it becomes necessary in larger plants to employ more firemen, or to install stokers and a gravity supply of coal from overhead storage. It may not be possible in all altered boiler plants to install over-

*Chief engineer of Link-Belt Co., Philadelphia and Chicago.

head bins and spouts, but where it is possible, managers should consider not only the first cost of bins and conveyors, but also the fact that the wages of common labor are increasing each year, that in many places it is difficult to hire men for the hot and laborious job of firing boilers by hand, and that it generally pays to invest $5000 in bins and conveyors for every fireman or coal passer whose services can be rendered unnecessary.

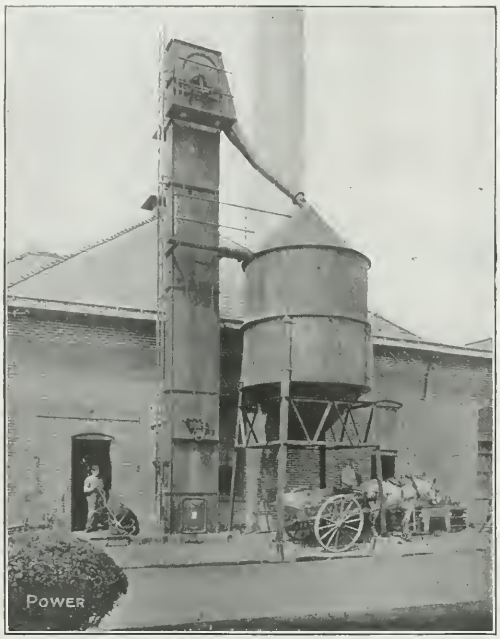


Fig. 5. An Ash Elevator and Storage Bin

If overhead storage is decided on, the bins can be separate for each boiler, or one long bin can be used. The latter is the cheapest way to get a large amount of storage, particularly if the bin is of the suspension or bag-

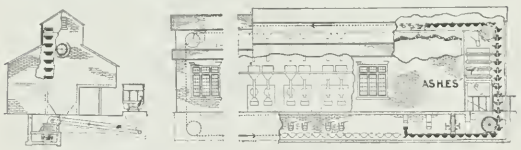


Fig. 6. An Installation Similar to That of Fig. 4

bottom form. The bin should be high enough to permit boiler tubes to be cleaned or removed, and there should be room enough over the bin to put in the coal conveyor. The bin can be filled by a separate coal conveyor, but since in most large plants the problem of quickly disposing of ashes is an important one, a convenient way is to combine the coal conveyor and the ash conveyor in one, and use a machine of the pivoted-bucket type. Figs. 4 and 6 show typical installations of pivoted-bucket carriers. These include a track-hopper dump, a feeder of some kind, a crusher and the carrier taking coal from the crusher and delivering it to the overhead bins, or taking ashes from the hoppers under the boilers and delivering them to the ash storage overhead. If there is no basement for the lower run of the carrier, or if hoppers cannot be built under the boilers, all that is necessary is a trench in the boiler-room floor to receive the carrier. Ashes are then raked from the boiler ashpits into the lower run of the carrier.

Pivoted-bucket carriers are of several forms. A type quite commonly used has overlapping lips, see Fig. 7, to prevent the spill of material between the buckets. Cams or strikers on the ends of the buckets engage a dumper which travels along the top run, and the contents of each bucket are poured out at any point desired.

These general remarks may throw some light on the methods to be adopted in installing coal and ash machinery in boiler houses which now burn oil. Each plant will present some peculiarity of location or of arrangement, which will call for particular treatment and the experience of engineers trained to this kind of work.

The Sturtevant Air Washer

The new Sturtevant air washer, Fig. 1, which has been on the market a little over a year, is of the rain-spray type, with horizontal eliminators. It consists of three parts, the spray chamber, in which the washing actually occurs, the eliminators, which remove all entrained moisture from the air and the sump, or tank, which forms the bottom of the air washer and into which falls all of the air from the syray pipes and the eliminators.

Besides these parts, there is a recirculating pump for creating a circulation of water in the spray pipes. When installed in a ventilating system, the arrangement shown in Fig. 2 is used. The air enters at the left, passes through a tempering coil and heater into the air washer and from thence through a second heater into the fan. The pump and water piping are shown and a portion of the casing is broken away, showing the eliminators of the air washer.

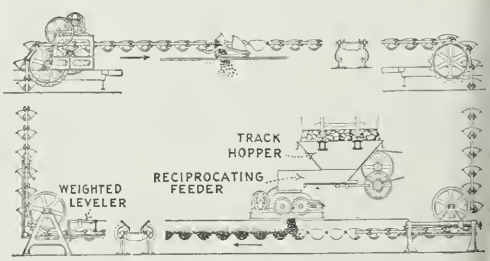


Fig. 7. A Form of Pivoted Bucket Carrier

The type of nozzle forming the spray in the air washer, which is made by the B. F. Sturtevant Co., Hyde Park, Boston, Mass., is shown in Fig. 3. Fig. 4 shows how these are attached to the spray pipes. The design of these nozzles permits of a large orifice which prevents clogging, and no flushing device is required with this type of nozzles. The water issuing from the orifice under pressure created by the recirculating pump strikes against a lip curved over this orifice and is broken into a spray, spreading out broadly, due to the shape of the lip and thus completely filling the chamber. The water falls into the sump below. The spray chamber is constructed of gal-

vanized steel and the interior is painted with black asphaltum.

The air passing through this rain-like spray is cleansed of dirt and impurity and finally comes in contact with the eliminators, whose position in the air washer can be seen in Fig. 1, and whose shape and construction can be seen in Fig. 5. These eliminators are placed horizontally across the air washer and form between them, broken passages through which the air must pass in order to leave the spray chamber.

The surface of each of the eliminators is perforated in such a way that small lips of metal are formed and that the edge of each eliminator is serrated. The air laden with moisture strikes against the edges of these serrations and perforations and against the edges of the metal lips where the entrained moisture is removed so that when it leaves the eliminators, the air contains no unevaporated moisture. The water dripping from these eliminators further

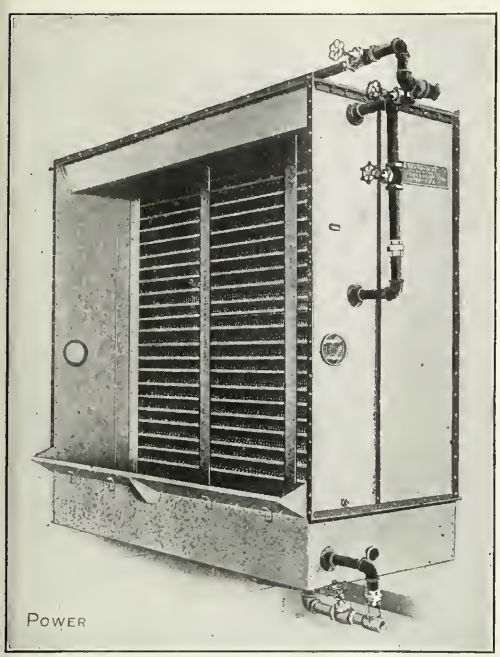


FIG. 1. STURTEVANT AIR WASHER

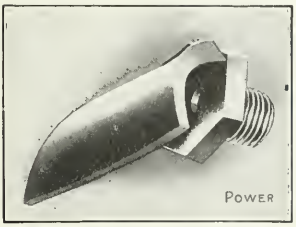


FIG. 3. SPRAY NOZZLE OF AIR WASHER

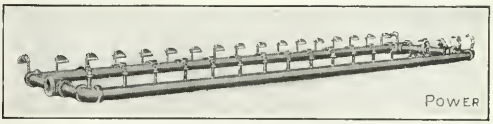


FIG. 4. SPRAY PIPE SHOWING NOZZLE ATTACHMENT

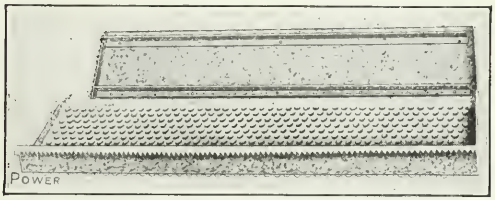


FIG. 5. ELIMINATOR OF AIR WASHER

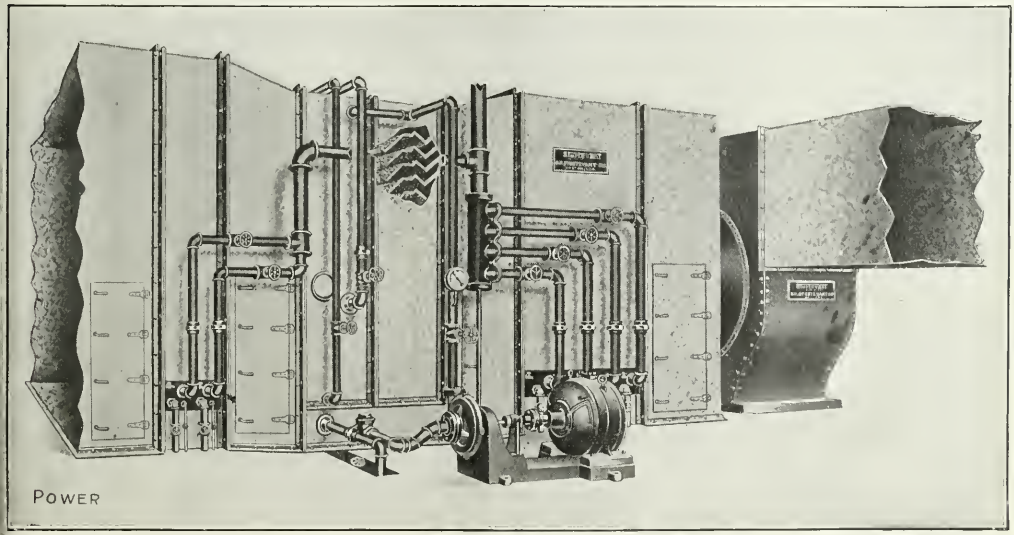


FIG. 2. AIR WASHER ARRANGED WITH TEMPERING COIL, HEATER AND FAN

increases the efficiency of the washing process and drains into the sump below. The eliminators are constructed of galvanized steel, galvanized after being punched and formed, and painted with black asphaltum.

The sump, which may be constructed of galvanized iron or of concrete, is a tank into which falls the water from the spray chamber and eliminators. It is provided with an overflow which maintains a constant level of water within and with a drain and strainer. A float valve maintains the water supply. The water is drawn from the sump by a small centrifugal pump, shown in Fig. 2, and is delivered by this pump to the spray pipes under sufficient head to create the desired spray. The pump may be driven by electric motor, pulley, belt, steam engine or steam turbine.

The strainer consists of two concentric, perforated cylindrical screens inclosed at the ends by aluminum castings. The pump-suction pipe draws the water within the two screens. As the orifices of the nozzles are comparatively large, the mesh of the strainer is not so fine that excessive power is required to drive the pump and as a second wire strainer in the washer pipe is unnecessary, another saving in power for the pump is thereby effected.

The Ohio Society

The Ohio Society of Mechanical, Electrical and Steam Engineers held its 28th meeting at Columbus, Nov. 20-22. Thursday forenoon the arriving members gathered at the Southern Hotel for registration, and in the afternoon visited the Seagrave Co., makers of auto-truck apparatus for fire departments, and the Buckeye Steel Castings Co., while the ladies were taken about the city in automobiles. On Thursday evening a professional session was held at the auditorium of the Southern Hotel, at which Geo. S. Cooper, mechanical engineer, of the Buckeye Engine Co., of Salem, Ohio, read a paper upon "An American Locomobile," describing the first American locomobile, or the Buckeye-Mobile manufactured by that company and described in "Power" for May 20, 1913. The portions of the paper other than the descriptive will be reproduced in an early issue. Remarks were made by Mr. Bassell, of the Columbus Publicity Association, and Mr. McMean, president of the street railway. Friday was spent at the Ohio State University, where, in Townsend Hall, a meeting of the council was called for 9 a.m., followed by a business meeting of the society, at which W. C. McCracken, chief engineer of the Ohio State University, was elected president; W. L. Brown, of Toledo, vice-president, and Geo. S. Cooper, of Salem, Ohio, and Dan Delaney, of Cincinnati, managers for the ensuing year. Following the business meeting a paper upon "Steam Flow Meters" was presented by Irving B. Terry, of the Cincinnati office of the General Electric Co.

The afternoon was devoted to an inspection of the engineering laboratories and plants of the university, with a lecture by Francis G. Caldwell, professor of electrical engineering at the university, upon the "Quartz Tube Mercury Vapor Lamp."

The visitors were the guests of the local committee at the Union, the University Club House, at luncheon and dinner. In the evening a professional session was held in the Physics Building, at which papers upon "Accident Prevention," by Fred G. Bennett, head of the Safety Department of the Buckeye Steel Castings Co.; "Recent Developments in Electrical Transmission," by Geo. N. Lemmon, general manager of the Transmission Engineering Co., of Pittsburgh, and a paper upon "Carborundum," by Chas. Boultman, of the Carborundum Co., were presented. Meantime, the ladies attended the theater. On Saturday visits were made to the Automatic Exchange of the Citizens' Telephone Co., the filter works and pumping stations, and other local industries.

NEW PUBLICATIONS

GAS AND FUEL ANALYSIS. By Alfred H. White. Published by McGraw-Hill Book Co., New York, 1913. Cloth, 5½x8 in.; 276 pages, 47 illustrations, tables. Price, $2 net.

The ever-spreading tendency to control industrial processes by scientific investigation of the character of the materials handled makes this volume timely. Gas analysis is a useful method of controlling the operation and checking the efficiency of boilers, producers, gas-making plants, etc. To get the greatest benefit, the analysis must be as nearly accurate as possible. The author points out many causes of error not commonly recognized and rarely fully appreciated. For instance, it is reasonably well known that plain water has ability to absorb CO_2, but it is not well known that the error due to the absorption of CO_2 from the sample of flue gas collected over water may amount to as much as 50 per cent. of the CO_2 content of the gas if the water is not saturated with the gas being tested.

The book contains many useful hints on handling the apparatus required. To illustrate, it is pointed out that the stop cock of a gas burette, a source of frequent error and trouble, should be kept clean and well lubricated. The author states that vaseline, commonly employed, is inferior, and favors anhydrous lanolin. Rubber connections cannot be relied upon to remain gas-tight for long periods of time, and it is recommended that all such connections be reinforced by soft copper wire wrapped once around the connection and clinched.

Both absorption and explosion and combustion methods of determining the content of hydrogen, methane, ethane and carbon monoxide are discussed. The chapter on the absorption reagents employed is valuable, because it points out their limitations.

In the chapter on gas calorimetry the available methods and types of apparatus are discussed and considerable space is given to the design and operation of Junker's continuous-flow calorimeter. In another section gas photometry in considerable detail is taken up; several types of photometers are described and the methods of procedure fully explained. Separate chapters deal with estimating suspended particles in gas, chimney- or flue-gas analysis, producer-gas and illuminating- and natural-gas analysis.

The chapter on liquid fuel takes up the usual tests applied, such as for heat value, specific gravity, moisture, suspended solids and flash point.

SOME OF THE ATTENDANTS AT THE COLUMBUS MEETING OF THE OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

The sampling, analyzing and testing for heat value of coal is treated in three chapters or 66 pages. Interesting data are given relative to the possibility of error due to sampling. One illustration of possible error even with what many would consider adequate care is particularly interesting. A lot of three tons of run-of-mine coal was moved in wheelbarrows.

As each barrow was filled a shovelful of coal was put into each of 16 sampling barrels. After the coal was moved, the barrels each contained about 125 lb. of coal. These samples were crushed and sampled carefully and the ash in each determined. Only two of the samples exactly agreed while two disagreed by 4.46 per cent. In one case the ash content was shown as 9.46 per cent. and in the other 13.92 per cent.; the average for all 16 analyses was 10.68 per cent. The possibility of error induced by the presence of lumps of slate in the coal and the influence of size are also strikingly brought out. The chapters on coal analysis and heat value go into considerable detail and several types of calorimeters are discussed.

This is the most complete and exact modern treatise on the subjects embraced that has come to the notice of the reviewer. The book shows that the author is thoroughly familiar with the work in both its academic and practical phases and hence will be found of service in commercial as well as scientific practice.

HANDBOOK FOR HEATING AND VENTILATING ENGINEERS. By James D. Hoffman. Published by McGraw-Hill Book Co., New York City, 1913. Flexible leather cover; 402 pages, 4½x7 in.; 157 illustrations; tables. Price, $3.50, net.

This is the second edition of a handbook which covers the entire field of heating and ventilation, with two chapters on refrigeration. The first edition appeared in 1910. For the present edition all the material has been revised to bring it up to date. The work on air conditioning has been amplified. Descriptions of hot-water and steam heating have been improved by diagrams of the various piping systems. Two chapters have been added on refrigeration, and also a number of useful tables in the appendices. The first chapters of the book deal with elementary considerations, such as the measurement of heat and temperatures, composition of air, humidity, measurement of air velocity, etc. This is followed by a chapter on heat losses from buildings, and methods of estimating the radiating surface required. The information given in this chapter is excellent, as the computations for hot-steam and hot-water systems are treated in the same way. In the days of vapor systems operating on low temperature steam it is illogical and incorrect to assume that steam systems require any more or less radiation than hot-water systems when operated under like average temperature conditions. Considerable space is given to hot-air furnaces, which should be appreciated by those engaged in that line of work. There seems to be the same doubt and confusion as to requirements of heating surface for the hot-air furnace, as occurs in the cast-iron boiler trade. The book is lacking in definite data on both furnaces and heating boilers outside of the general ratios of grate to heating surface. This information does not appear, however, in any of the current literature on the subject, and is very probably a reflection of the attitude of the boiler manufacturer in not giving this important item in his catalog. Along this line attention is called to results of a test on an American Radiator Co.'s boiler given in the second appendix of the book. The data may perhaps shed some light on how some of the catalog ratings are obtained. In a boiler containing 300 sq.ft. of heating surface an evaporation of 5.6 lb. per sq.ft. of surface per hr. was given. Assuming that this evaporation is from and at 212 deg. F., it would require only 6.12 sq.ft. of surface per horsepower, as compared to 10 sq.ft. for the best power boilers. This would make the evaporation per square foot for a power boiler 3.45 lb. as compared to the 5.6 lb. given above. Ordinarily the efficiency of a power boiler should be higher than that of a cast-iron boiler, and especially when the stack temperature of the latter reaches 725 deg., which was the figure given in the test.

The various systems of hot-water and steam heating, mechanical warm-air heating and district heating, are given extended attention. This is followed by a chapter on temperature control, a chapter on electric heating, two chapters on refrigeration, a chapter dealing with specifications, and two appendices giving a number of valuable tables and diagrams. The chapter devoted to district heating, although possibly reflecting past practice in the West, is rather misleading in some respects as to the possibilities of central heating by hot water. It is stated that "With perfected apparatus for removing oil, the commingler will no doubt supersede to a degree the tube reheaters in hot-water heating." On the next page it is stated that the pressure in the radiators is greater in water systems than on steam systems, especially when connected to high buildings. The use of a commingler precludes any very high building heating, due to the fact that there is an open circuit, and all water has to be pumped against the total static head and friction head of the piping, which is, of course, very uneconomical. In a diagram showing the power-plant layout in connection with a hot-water heating system, piston pumps are shown, although they have been discarded by all modern engineers for this class of work, and with a live-steam heater it is unnecessary to have any of the boilers arranged for water circulation as shown in the illustration.

In the tabular matter Peabody's tables giving properties of steam have been used rather than the tables of Marks & Davis, which have now been more generally accepted as standard. The properties have not been given below 1 lb. abs., although in air conditioning they are needed down to 32 deg. F. Wood's tables giving the properties of ammonia have also been used rather than the later, and more accurate data brought out by H. J. MacIntire, or the tables of G. A. Goodenough and William E. Mosher, published in a bulletin of the University of Illinois Engineering Experiment Station.

As a whole, the book is excellent and admirably adapted for reference or to supplement more specialized works. At the end of each chapter references to technical books and periodicals are given, which alone are worth the price of the book, and with every copy a pamphlet is included containing suggestions and problems for a course of instruction in technical schools. The latter feature should be appreciated by the instructor, and of value to the practical man or student, as answering the numerous questions given will test their knowledge of the subject and indicate their deficiencies.

Space Occupied by Water-Tube Boilers is the title of an interesting pamphlet which has recently been issued for general distribution by the Heine Safety Boiler Co., of St. Louis. This publication is a reprint of a paper read last April by C. R. D. Meier, general sales manager of the company, before the Associated Engineering Societies in St. Louis. The paper considers the influence of tube size and arrangement, gives the dimensions of seven water-tube boilers of the same rated capacity, the comparative floor space required for a typical installation of eight boilers of the various types, discusses the money value of floor space and head room and finally the total saving per boiler horsepower from the standpoint of floor space and head room saved.

⁂

Class in Heating and Ventilation

A class in the science and practice of heating and ventilation will meet Monday evening of each week at 7:30 o'clock, in Room 511, World Building, New York, and the course will be under the direction of a competent heating and ventilating engineer, who is engaged in the design and installation of systems for all classes of buildings, and is well fitted to offer the best instruction in the most recent practice. The course will consist of 22 lectures covering the subjects of heating and ventilating, with special reference to such topics as purification of air; types of heating systems; computation of heating surfaces; pipe sizes; ducts; fans; radiating surfaces, etc. The fee for the complete course will be $10, payable in advance.

The first meeting was held on Dec. 1, at 7:30 p.m., to organize regular classes, and the lectures started the following Monday evening.

⁂

Power Companies at Sault Ste. Marie, the Michigan & Lake Superior Power Company and the Algoma Steel Corporation, were given hearings on Oct. 7 by the International Joint Commisions, on their applications to be allowed to divert water at Sault Ste. Marie by an international dam.

⁂

A Power Plant at Great Falls, in the Potomac River near Washington, is to be built if Congress is favorable to a recommendation to be made to it by the Commissioners of the District of Columbia. The commissioners have included in the District appropriation bill an item of $3,000,000 to provide for the purchase of the falls and the beginning of the work, the total cost of which, it is estimated, would be $15,000,000.

⁂

A rubber belt 700 ft. long, 2 ft. wide, and tipping the scales at 5140 lb., was recently made by the Goodyear Tire Rubber Co. Akron, Ohio. It is to be used as a conveyor belt. When made into a roll it made a diameter greater than the height of an average size man.

Life of Isolated Plants

At the meeting of the New York Society of Architects, Nov. 18, at the Engineering Societies Building, New York City, Charles M. Ripley, with the firm of Pattison Brothers, consulting engineers, gave a talk on "The Life of Private Electric Plants and Are They Popular?" Investigating a list of about 150 of the large buildings in New York, selected impartially from a tax list, it was found that, as measured by assessed valuation, 78 per cent. furnish their own current. These buildings were of all kinds, including office buildings, apartments, hotels, theaters, railroad stations, clubs, etc. Naturally among such buildings as hotels and railroad stations where the hours of service are most continuous the percentage of private plants is high, while nearly all theaters and other places having need of current for relatively few hours in the twenty-four, purchase it.

The remainder of the talk, dealing with the life of plants covered two divisions, one a search and the other an investigation. The search was for the oldest plants in New York City still operating. The oldest located was that in the Mills Building, which has been in operation 32 years. Others ranged from this length of life down. As it was impossible to tell how many plants had gone out of existence in this time, it was believed unfair to draw conclusions as to the life of plants from the survivors, these being possibly the exceptions. The investigation, therefore, covered all the plants installed by the one firm of engineers to whose records the speaker had access, and extended back over twenty-three years. None of the plants designed by this office are dead. All but two are still operated and the two exceptions are not dismantled, but are retired for the present.

To draw conclusions as to proper rates of depreciation the speaker had asked Edward M. Hyams, president of the Certified Audit Co. of America to give him the number of years required for a sinking fund to equal the original investment; the sinking fund to earn 4½ per cent. interest, compounded annually.

This was given as in the following table:

Depreciation charged off annually	Years required to refund investment
1½	Between 31 and 32 yr.
2	26 and 27 yr.
2½	23 and 24 yr.
3	20 and 21 yr.
3½	18 and 19 yr.
4	17 and 18 yr.
4½	15 and 16 yr.
5	14 and 15 yr.

From this the following was figured:

SUMMARY OF PROBABILITIES

34 plants designed before 1900, 5% depreciation too much.
29 plants designed before 1898-9, 4½% depreciation too much.
17 plants designed before 1897, 4% depreciation too much.
15 plants designed before 1895-6, 3½% depreciation too much.
4 plants designed before 1893-4, 3% depreciation too much.
1 plant (N. Y. "Herald") 3% (may or may not be) too much.

SUMMARY OF POSSIBILITIES

Plants installed between 1883-1900

16 show less than 3 per cent. depreciation.
12 show less than 2½ per cent. depreciation.
4 show less than 2 per cent. depreciation.
1 shows less than 1½ per cent. depreciation.

Cover of Receiving Tank Injures Two

Excessive pressure in a large exhaust steam receiver used to distribute steam for heating the building of the Fremont (Ohio) Furniture Co., blew off the handhole cover. It divided into a number of small pieces, some of which hit the engineer in the face and cut his cheek and chin. An employee of the plant received the full force of the escaping steam and was badly scalded on the face, neck and left arm. Both were removed to their homes and will be confined for some time.

New Haven A. S. M. E. Meeting

The New Haven local meeting of the American Society of Mechanical Engineers was held in the Mason Laboratory of the Sheffield Scientific School, Yale University, Friday, Nov. 21, 1913. At the afternoon session the general topic was "Co-operative Industrial Research." E. S. Cooley, supervisor of power plants of the New York, New Haven & Hartford R.R., the Connecticut Co., and the Housatonic Power Co., and chairman of the local committee on meetings, presided.

The subject was introduced by Dr. L. P. Breckenridge, professor of mechanical engineering at the Sheffield Scientific School, by outlining the relations of this school to Connecticut manufacturers and others in the carrying out of industrial research. O. P. Hood, chief mechanical engineer of the United States Bureau of Mines, followed with an explanation of the research work of the bureau and W. K. Shepard, representing the Engineering Experiment Station of the University of Illinois, read a paper on "Coöperation of State and University for Industrial Research."

In the interval between the afternoon and evening sessions and again after the evening session opportunity was afforded to witness demonstrations in the laboratory of oxy-acetylene cutting and welding by Henry Cave, president of the Autogenous Welding Equipment Co., Springfield, Mass., the new automobile-testing apparatus in the laboratory and recent types of pneumatic tools.

At the evening session an address was made by Calvin W. Rice, secretary of the American Society of Mechanical Engineers, in the course of which he announced some of the special features of the annual meeting of the society to be held in New York City, Dec. 2-5, and referred to the growth of the society in recent years.

The papers which followed included one on tests of safety devices used in connection with grinding wheels, by R. G. Williams, of the Norton Co., Worcester, Mass.; an analysis of the difference in conditions here and abroad as affecting the protection of life and limb of the people and the taking of precautions for safety by Dr. A. D. Risteen, of the Travelers' Insurance Co., Hartford, Conn.; and one on the manufacture of brass, comparing practice in Austria, Germany, France, England and the United States, by W. B. Edwards, of Ansonia, Conn.

Two other papers scheduled for the meeting had to be omitted on account of shortness of time. One of these dealt with experiments with residence-heating boilers by D. B. Prentice, of the Mechanical Engineering Department of the Sheffield Scientific School, and the other with motor-car testing by E. H. Lockwood, assistant professor of mechanical engineering at Sheffield.

At the evening session, which was the larger of the two, there were about 250 persons present.

SOCIETY NOTES

At the semimonthly meeting of the Detroit Engineering Society, on Dec. 5, James V. Oxtobyon will read a paper on "The Relations of the Engineer to the Law." On Dec. 19, the society will discuss a new constitution.

On Wednesday evening, Nov. 19, the Chicago section of the American Society of Mechanical Engineers held the first of a series of informal dinner-discussions planned for the 1913-1914 season, in the Crystal room of the Sherman Hotel. The topic was "The Steel Industry," the discussion being led by W. A. Field, general superintendent of South Works of the Illinois Steel Co. Over 150 members and guests sat down to the dinner at 6:30 o'clock. The occasion was distinguished by the presence of President W. F. M. Goss, Past-presidents R. W. Hunt and Ambrose Swasey. Among the other speakers were Edward McKim Hagar and H. J. K. Freyn. Paul P. Bird presided.

PERSONALS

John Thompson, formerly chief engineer for the State Normal School, Trenton, N. J., has been appointed chief engineer for the new City Hospital, in Newark, N. J. Mr. Thompson has already assumed his new duties.

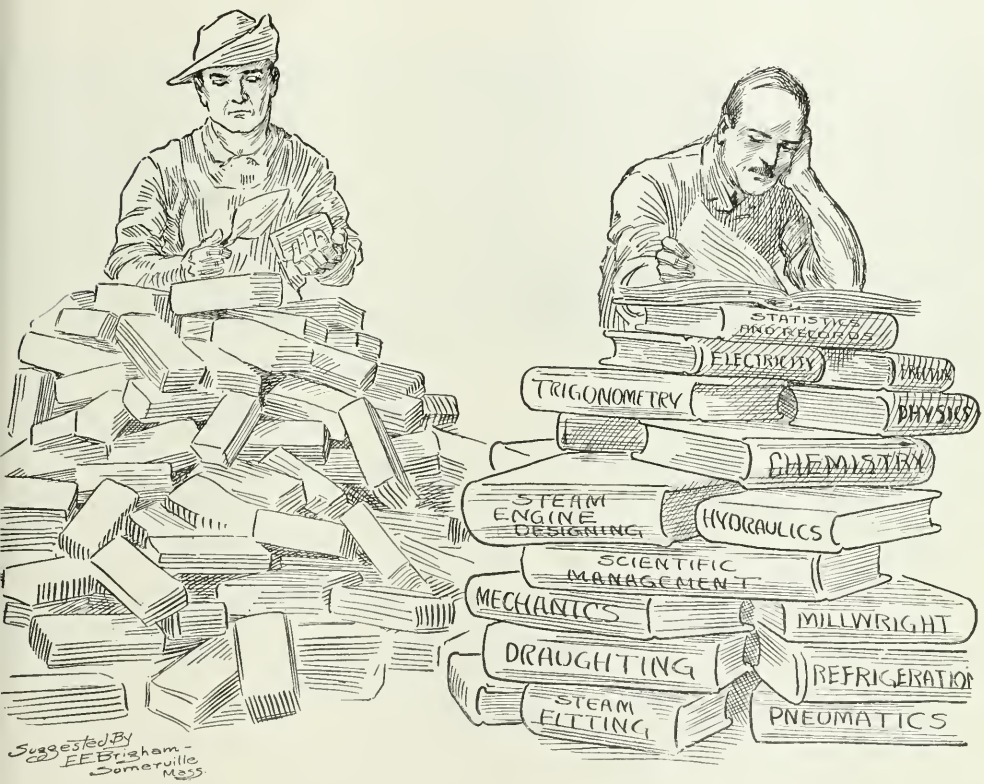
William A. Vreeland, of Newark, N. J., formerly chief engineer of the L. Bamberger Co. department store, Newark has been appointed inspector for the Passaic Valley Sewerage Commission. Mr. Vreeland will have charge of all mechanical equipment and buildings connected with the pumping and disposal of sewage carried by the large trunk sewer.

C. L. Newcomb, Jr., will succeed G. B. Turner as Western representative of the Goulds Manufacturing Co., Seneca Falls, N. Y., with headquarters at 12 Chamber of Commerce, Denver, Colo. Mr. Newcomb will look after the company's interests in the Rocky Mountains and Northwestern territories. He has had several years' experience in the pump business and is well known in the territory he will travel.

POWER

Vol. 38 NEW YORK, DECEMBER 9, 1913 No. 24

The Materials They Build With



IS THEIR COMPENSATION IN PROPORTION?

Tropical Feed-Water Filter Plant

By C. Carlton Semple

SYNOPSIS—Description of a feed-water filter plant in the tropics, made necessary by the decomposition of rock and organic matter from decaying vegetation. The filter consisted of three tanks in which suitable filtering material was placed.

One of the perplexing problems to be solved in steam power-plant practice in the tropical lowlands is that of obtaining a sufficient supply of clean water for the boilers. The solution, however, is generally simple once the underlying principles are fully comprehended.

In most tropical regions, at low elevations, the rainfall is heavy, exceeding 120 in. per annum, and while it frequently rains more or less during eight or nine months of the year, by far the greater part falls in four or five months, usually in downpours of only a few hours' duration. Immediately after such heavy rains the rivers become flooded. The densely wooded, almost impenetrable jungle, would seem to be capable of holding this water for a long time, but the soil, consisting often of the clayey products of rock decomposition, retains moisture practically to the degree of saturation at all times, and the sun never reaches the ground to hasten evaporation. It is the slow seepage of water through the clayey soil that supplies the rivers with the water which flows through them at times of low water level.

It is the slow seepage water that is temporarily retained in the soil and not the rapidly drained flood waters that the engineer has to rely upon for boiler feed. This water remaining in long contact with the decomposed rock of which the soil consists, becomes impregnated with soluble salts, and becomes surcharged with organic matter from decaying vegetation. It also takes up minute particles of rock material. For these reasons boiler-scale troubles are apt to be experienced whether or not there be limestone in the vicinity.

A case in point was experienced by the writer at a mine power plant in Nicaragua, when upon taking charge he found that a 30-hp. locomotive-type boiler which was supposed to be capable of generating enough steam to operate all the machinery in the 100-ton mill, could not supply steam enough to keep more than half the machinery going at full speed.

The first thing to be ascertained was the nature of th scale, which was made up of alternate bands of differe thicknesses of red and white material. The red materi was granular, the white compact and both very hard. test with hot and cold strong hydrochloric acid failed t show effervescence, which would have indicated the pre ence of carbonates, probably of magnesia and lime. Th glasses in which these tests were made were left standin over night, and the next morning the scale was found t have dissolved in the acid and to have formed a heav gelatinous mass, indicating that the scale was made u chiefly of a certain class of minerals held in suspensio and not of salts in solution in the water.

This simple test indicated that the remedy and th preventive for the trouble consisted in removing the har scale already in the boiler and eliminating the fine ma terial from the feed-water supply. The scale was entirel too hard to be removed by any scraping or punching too that could be operated through the handholes, and t

Fig. 1. Feed-Water Filter Tanks

Fig. 2. Hauling Fuel to the Boiler House

have taken out the tubes would have delayed operatio for six weeks, causing a loss in production of $6000 i gold, because no extra tubes were on hand and a ne set would have had to be ordered from New Orleans.

Several commercial brands of boiler compounds ha previously been tried with indifferent success. After a certaining the source of the trouble the boiler was fille to a point a few inches above the top row of tubes wit water after about one gallon of kerosene had been poure in through one of the handholes. The boiler was the fired up and a pressure of only 30 lb. maintained, whi no attempt was made to run the plant. The blowoff w opened for a short period every three hours and the wat level reëstablished. After three days the fire was draw and all the scale that had loosened was removed.

After a second treatment the boiler was placed in reg lar use and every morning one-half pint of kerosene w added to the feed water. For the first six weeks the f was drawn every week and the loosened scale removed. few weeks after this treatment had been started it w possible to run all of the machinery part of the time a half of it all the time at full speed. After two mont all of the machinery could be kept running all the ti at good speed. After seven months a larger 80-hp.

turn-tubular boiler was ready to be put in commission. The small boiler was then retubed, and it was found that practically all of the scale had been removed from between the tubes by the kerosene treatment, but none had been removed from the crown-sheet.

Wood was used for fuel and drawn to the plant on sledges, Fig. 2.

When the new boiler was put into commission the question was raised as to whether or not any corrosion was

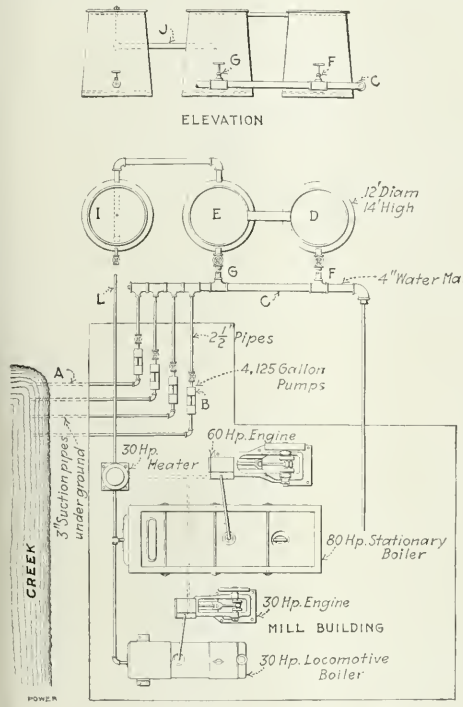


Fig. 3. Piping of the Filter Tanks

caused by the water. Before firing up, all the outside surfaces of the tubes and the inner side of the boiler shell was rubbed over with flake graphite until a very thin glossy coating covered the metal. This was done not so much with the idea of preventing corrosion as to prevent any scale from adhering. Later when the smaller boiler was retubed no evidence of corrosion could be discerned in the old tubes, nor was any such evidence discovered in either of the boilers at any time thereafter.

Meanwhile a filtering plant was installed to remove the solids in suspension in the water taken from the creek for the boiler-feed supply. This plant was exceedingly simple and required only one 12x14-ft. wooden tank in addition to the two 14,000-gal. tanks that held the mill-water supply, Fig. 1. These were arranged as shown in Fig. 3, in which *A* is the 3-in. suction pipe from the creek to the four pumps; *C* the 4-in. water main that supplied the mill with water and which was connected at one side and near the bottoms of the mill-water tanks *D* and *E*, the connecting pipes being controlled by the valves *G* and *F*. The tanks *E* and *D* were connected at the tops by a trough, about 6 in. deep. The filter tank *I* was connected with the tank *E* by the 4-in. pipe *J*, about midway between the top and bottom of both tanks, and extended across the tank to the opposite side, the end of the pipe within the tank having been plugged and the pipe itself drilled with many ½-in. holes, Fig. 4. The valves on the mill-water main were normally wide open, so that the speed of the pumps had to be so adjusted that all three tanks remained full of water.

Normally the valve *G*, Fig. 3, was closed and the valve *F* left open, so that the water entered the tank *D* at the bottom, rose in it to near the top, thence passed over into the tank *E*, through the trough and rising in the tank *E* to the height of the pipe *J*, flowed into the tank *I*. In rising through the tanks *D* and *E* the coarser solids had ample opportunity to settle, and the sludge thus accumulated on the bottom of those tanks was periodically flushed out through suitable valves.

The bottom of tank *I* was provided with a filter, which, as shown in the section of that tank, Fig. 4, consisted of a grating 1½ in. less in diameter than the diameter of the tank. This grating was made up of 2x2-in. scantling laid upon two sets of timbers 12 in. deep, so that the bottom of the filtering bed was 24 in. above the bottom of the tank. Upon the grating a double layer of thin, white cloth, which in all tropical countries is sold under the name of *manta*, was tacked in place and the grating calked by a piece of hemp rope driven down between the

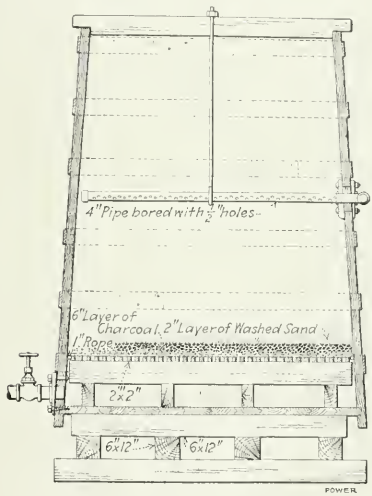


Fig. 4. Details of Construction

edge of the grating and the sides of the tank. On the cloth was spread a layer of screened charcoal 6 in. deep, the pieces of which were not less than ½ in., nor greater than 2 in. in diameter. Upon the charcoal was spread a layer of washed river-sand containing no particles that would pass a screen with 20 meshes per linear inch. This sand sank into the spaces between the lumps of charcoal, but was, on the average, 2 in. deep. The layer of charcoal was used only to prevent too tight packing of the sand upon the filter cloths.

After the filter has been in use for a week or 10 days

upper surface becomes coated with a thin gelatinous coating of vegetable growth which, while allowing water to percolate through it, entangled the finest sediment and prevented it from passing through the filter bed.

The water below the filter tank *I*, from which all sediment had been removed and which was crystal clear, was drawn off through the pipe *L* to a 30-hp. feed-water heater, from which all the plates had been removed. All of the exhaust steam from one 60-hp., one 30-hp. engine and four service and four boiler-feed pumps was led into it, heating the feed water to 210 deg. F., before flowing to the pumps. The bottom of the heater was about 2 ft. above the four pumps, so that the water flowed to them by gravity. The feed water was fed to the boiler constantly; one or the other pumps was always in motion night and day, the speed being so regulated that the feed equaled the evaporation.

After this system had been installed no further trouble was experienced from scale. It was the custom to stop operations the first and fifteenth day of each month, which were the mill clean-up days. Then the boilers were blown out and about half an ordinary water bucket of granular material would be found in the bottom. This was probably the salts held in solution in the water and which could, therefore, have passed the filter bed. No scale formed on the plates or tubes, and no corrosion was evident at the end of two years.

At these clean-up times the drain valves on the tanks would be opened to drain off the settled sand and sludge. The sand on the filter beds was removed and a new layer substituted every six months. The cloth in the filter had been in use 18 months when the writer relinquished charge of the work. The heater also served as a sand trap, inasmuch as it would have caught and held all the sand that might have been washed through a hole in the filter cloth and thus have prevented its entering the boiler had such a hole formed.

All the lubricating oil in the exhaust from the engines and pumps entered the feed-water heater, from which the plates and box for removing such oil had been taken out. Consequently much oil must have returned to the boiler and the quantity accumulated steadily for two weeks. A cheap mineral cylinder oil was used, but no trouble was experienced from its presence. On the contrary, the oil was regarded as beneficial rather than detrimental, as it probably caused salts that had been in solution in the water to settle as a granular sand rather than in a compact mass. The filtering capacity of one 12x14-ft., 14,000-gal. filter tank was just sufficient for the two boilers. The water percolates very slowly.

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Modern Boiler-Room Operation*

By W. A. Bloxck

SYNOPSIS—Application of the Ohmic-law principle to boiler operation. Opportunities for improving average present-day boiler-plant efficiency by means of suitable instruments enabling operators and chief engineer to know condition of furnace at all times. Two bonus systems that failed and one that was successful.

❖

The erroneous idea appears to prevail that it takes brain to run an engine room while just brawn is sufficient for the boiler room. This point is brought home upon entering a turbo-generator plant and seeing an equipment of instruments on the generator panel representing an expenditure of from $1000 to $2000. Even the worst operator cannot decrease the efficiency of the prime movers more than about 2 per cent., while in the boiler room the loss in economy due to ignorance or lack of suitable indicating and recording apparatus may amount to as high as 30 per cent., or even more. Yet, in most boiler rooms a steam gage and water glass are the only instruments provided. About 50 per cent. of the cost of operation of most power plants is chargeable to the boiler room, and for the handling of this expenditure the management often employs the lowest grade of labor available, instead of giving inducements to the intelligent workman to stay in the boiler room and handle this expenditure judiciously. Another point for criticism is that in many industrial plants the power-generating expense is charged entirely to overhead expense and the power house is not treated as a separate department, receiving a certain sum every month for the raw material (coal) and giving a finished product (power) with a certain net return. In too many plants the cost data kept consist only of the coal bills and the weekly payroll. No check is made on the weight of the coal received neither is its heat value ascertained nor the evaporation it yields in actual service. And, as more than 50 per cent. of the entire expenditure for power is generally handled in this crude manner, it is no exaggeration to say that from a commercial standpoint the operation of two-thirds of our boiler rooms is to be considered as an economic joke.

As a concrete illustration, consider the horrible example of a smaller size of coal mine. Here an equipment of six very small tubular boilers is erected in the open air, just protected in front by a rain shed; the fire-doors close only partly; the settings are badly cracked; the rear arches have holes through which one could pass his fist; the flue-doors are without a latch, and the stacks are eaten through by corrosion. The duplex pumps employed have leaky valves and piston rings, resulting in a constant roar of exhaust steam passing out at the roof.

When the owner was informed that a simple and inexpensive fixing-up of his plant would result in a saving of 35 per cent. of the coal used, he paid no attention but merely remarked that the operation of the plant cost him nothing except for a little labor as the coal was found right near the ground.

Although this mine owner was prosperous, he certainly suffered from a warped mind and had a kink in his business make-up. He and other members of his class remind me of a saying current among the aristocrats of France just before the crash came at the end of the eighteenth century, which in plain English would run about as follows: "Let us enjoy and waste today, we do not know what tomorrow will bring and we do not care who comes after us."

*Abstract of lecture before Illinois Association No. 28, Chicago, of the National Association of Stationary Engineers, Nov. 1

Looking at the reverse of this picture, it requires no great strength of imagination to predict that a few centuries hence some college professor at the head of his class will lift an incandescent bulb and make a remark about as follows: "This was the means of light in the twentieth century. It was produced from the energy stored in coal with an efficiency of 0.2 per cent. What would we not give if some of this precious energy had been left for us?"

Steam boilers have been employed for more than 200 years, yet it must be confessed that less is generally known about them than the electrical engineer knows about the practical forms of electricity, although the latter is a development of only about 25 years. In the evolution of his art, the electrical engineer soon realized that a quantitative and qualitative analysis of electrical energy was necessary and thus the Ohmic law soon became a tool easily comprehended by all workers in the art. A standard of measurement analogous to the Ohmic law can be applied to the operation of a boiler furnace. The draft resistance of the fuel bed can well be compared to a resistance in an electric circuit. The pressure or draft loss caused by the fuel bed can easily be compared with the voltage of the electric circuit and the amount of flue gases passing through the boiler can well be compared with the amperage in an electric circuit. This analogy is true to the extent that the amount of flue gases passing through a boiler is in direct proportion to the friction loss through the boiler, and in indirect proportion to the friction loss through the fuel bed.

Any device, such as the Blonck boiler-efficiency meter,* which gives the fireman or water tender information as to the resistance of fuel bed and loss in draft through the boiler, serves at once to show relative boiler output and efficiency.

One pound of coal burned with best efficiency in the Illinois district requires about 20 lb. of air. As the fireman can neither see, smell or hear when the correct amount is being supplied it often happens that four or five times as much is admitted, resulting in the cooling down of the gases and the necessity for a great amount of extra coal for no other purose than to heat the excess air supplied to the furnace and later passed to the chimney without adding one iota to the steam production for which the plant was built.

Then, there is the other possibility of supplying too small an amount of air. This results in incomplete combustion, producing carbon monoxide in the flue gases which has the same effect of lowering efficiency.

The *crux* of the entire combustion problem is to be able to regulate the amount of oxygen or air supply per pound of coal and to be able to tell instantly when the mixture relation changes to one producing waste. The Blonck meter makes the accomplishment of this result possible and by means of adjustable indicators may be set so that even a foreign laborer who cannot understand English can be quickly taught to regulate his furnace with the guidance of the meter.

To the ambitious engineer this and similar instruments are as important in the boiler room as the steam-engine indicator in the engine room, except that they have the added advantage that they give a continuous indication of the combustion process.

*Described in our issue of Dec. 24, 1912, and mentioned in that of Feb. 11, 1913.

As far as can be determined, there are two ways of getting the closer attention of the firemen. The first is the well known bonus system, and the second is to furnish the fireman proof that by firing correctly, which he can do with the assistance of proper instruments, he has to shovel less coal or can do better work with the exertion of less effort.

Bonus systems do not always work, as the following will indicate. A system was instituted in a high-grade plant of the Central West. The plant contained eight boilers, six being operated for average week-day loads. The coal used contained 10,000 B.t.u. per lb. and the firemen were shown how to keep a nice average of 8 per cent. CO_2. The bonus was to be $1 a week per man for each shift of firemen keeping an average of 8 per cent. and 25c. more for each additional ½ per cent. Inside of a week the bonus had boosted the CO_2 to 10 and 11 per cent. An investigation showed that it was now necessary to run seven boilers instead of six, and close coal and water records disclosed the fact that the evaporation per pound of coal had decreased instead of increased. The men simply worked for the bonus by keeping the damper partly closed and carrying very heavy fuel beds on the grates, thus reducing the rate of combustion per square foot of grate area and introducing the added losses due to greater radiation and the escape of unburned combustible gases. The system was abandoned as a consequence of this discovery.

In another instance a system was installed in a high-grade plant in the East having an accurate coal-weighing and water-measuring equipment. Each shift saw its previous day's record on a blackboard conspicuously located in the boiler room. The record simply gave total pounds of water evaporated, total pounds of coal burned and pounds of water evaporated per pound of coal. The feed-water temperature was practically constant for the three shifts. With 14,000 B.t.u. coal the bonuses were awarded for average evaporation of 8.5 or more pounds of water per pound of coal. The rivalry among the three shifts brought this value in a few weeks up to more than 9.75, and as that gave rise to suspicion, a watch was set, and it was found that this bonus system inspired the men to open the mud drums and blow frequently and generously to the sewer. As it did not seem advisable to provide locks and keys for the blowoff cocks, this system had also to be abandoned.

A bonus system which thus far has been free from temptations for the men to be dishonest is now being successfully operated in several plants of the Central West. Blonck boiler-efficiency meters of the indicating type are mounted on the boiler fronts and units of the recording type are installed under lock and key in the boiler-room foreman's office. As the recorders show graphically the relation at every instant between furnace resistance and boiler resistance, or in its last analysis, the amount of air admitted per pound of coal delivered to the grate, there is no chance for deception regarding the actual handling of the furnaces with its consequences relating to furnace efficiency and boiler capacity.

Mention of the fact that the gas-engine-driven exhausters, Fig. 9, of the Flatbush Gas-Electric Station article, Nov. 18 issue, were furnished by the Connersville Blower Co., was inadvertently omitted.

Sullivan Angle-Compound Air Compressor

As shown in the illustrations, Figs. 1 and 2, the angle-compound class "WJ3" air compressor has its low-pressure or intake cylinder in a horizontal plane, with the high-pressure cylinder set vertically, on the end of the horizontal frame. Both pistons are actuated by a single crank, and both sets of valve-gears by a single-eccentric pin. The driving pulley or motor is mounted at one side, on an extension of the crankshaft.

The main frame in this type of angle-compound compressor is horizontal, and supports the entire machine. To one end is attached the low-pressure cylinder and on the other is bolted an upright pedestal, which carries the vertical or high-pressure cylinder. This main frame is of the heavy-duty, Tangye pattern, with bored guides for the low-pressure crosshead. There are openings in the sides, to afford access. The bottom is solid and forms a reservoir for oil.

consisting of a babbitted box, carried in a heavy pillow block upon a sole plate bolted to the foundation. Set-screws and wedges permit adjustment both vertically and horizontally, so that this bearing may always be kept in correct alignment with the crankshaft bearings.

The band flywheel is of sufficient weight to give steady motion to the compressor, at its rated speed; it is made in halves.

When desired, the compressor may be driven by an electric motor mounted directly on the crankshaft. In this case the regular belt pulley is replaced by a heavy square-rimmed flywheel. A special crankshaft is supplied, of sufficient length to properly accommodate the electric motor.

Both low- and high-pressure cylinders are made with separate liners forced into the main castings, the spaces between the liners and cylinder castings forming the water jackets. The air passages in the cylinder casting cover the entire area outside of the jackets, the inlet and discharge sides being separated by longitudinal parti-

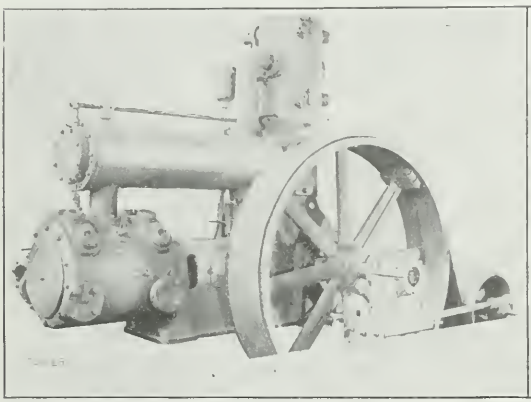


FIG. 1. VIEW FROM AIR END OF THE COMPRESSOR

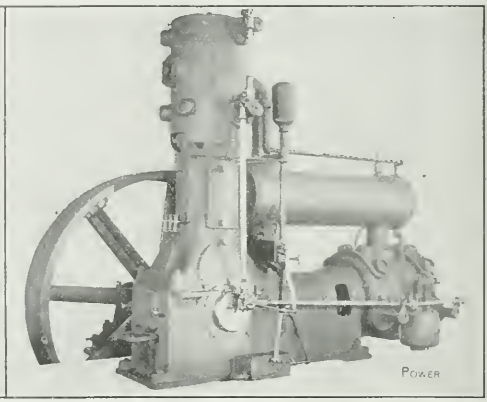


FIG. 2. VIEW FROM STEAM END OF THE COMPRESSOR

The vertical frame or pedestal is of similar design and has a broad base secured by heavy bolts to the top of the front end of the main frame.

The main bearings are made in four parts, of cast iron, lined with babbitt, with setscrew adjustment, and so designed that all four parts may be taken out without removing the main shaft.

The connecting-rods are forged from openhearth-steel billets, with marine-type boxes on the crankpin ends, lined with babbitt.

The crankshaft is a heavy, openhearth-steel forging, of the center-crank type. The crankpin is of a proper length to accommodate both connecting-rod boxes on it side by side. A heavy cast-iron counterweight is bolted to each crank cheek, equaling the whole weight of the reciprocating parts of either the high- or low-pressure member. The centrifugal effect of these weights neutralizes the inertia of both sets of reciprocating parts, so that the compressor runs at full-rated speed without perceptible vibration.

This crankshaft extends from one side of the machine to receive the driving pulley or motor, and in all except the smallest sizes, is provided with an outboard bearing,

tions on the sides of the cylinders. The surface on the outer side of the jacket walls provides considerable cooling area in addition to that of the intercooler.

The air-inlet valves are of the Corliss type, of ample area to fill the cylinder at atmospheric pressure when the compressor runs at maximum speed. The air-inlet valves are driven by steel valve stems equipped with collars with ground joints between these collars and the bonnets to prevent leakage of air around the stems. The stems derive their motion, through cast-iron rocker-arms keyed to them, from a single crankpin, attached to a small disk keyed to the end of the main crankshaft opposite the flywheel. The connection rods for operating the inlet valves are placed side by side on this pin, one rod reaching horizontally to the low-pressure valves, and one vertically to the high-pressure valves. All valve-gear connection rods have adjustable bronze heads for taking up wear.

The air-discharge valves are of the poppet type, internally guided on cast-iron plugs, and held to their seats by light steel springs; they seat in bronze cages, readily removable by unscrewing the valve plugs, and are sufficient in number to provide ample area for the escape of the compressed air from the cylinders. They are set

with their cages, in ports or pockets, arranged radially in the air-cylinder heads, and readily accessible for inspection or removal. As these valves act in a direction radial to the axis of the cylinder, they avoid losses in efficiency due to clearance space to the greatest possible degree. There are no long ports or pockets leading to them, in which air is trapped after compression instead of being expelled from the cylinder.

The intercooler, for removing the heat of compression in the air from the low-pressure cylinder, cylindrical cast-iron shell containing an amount of cooling surface sufficient to produce thorough cooling of the compressed air. It is located immediately over the low-pressure cylinder and frame, and has flanged inlet and outlet openings, and cast-iron flanged connections between it and the high- and low-pressure air cylinders. It is supported on its inner end by a hollow, cast-iron flanged leg, into which any accumulation of water or oil will drain. This water or oil may be blown off through a drain cock, provided at the bottom. A pop safety valve, attached to an opening on top of the intercooler, prevents unsafe pressure in the intercooler or low-pressure cylinder.

The intercooling surface consists of a nest of aluminum tubes through which the cooling water circulates, entering at one end, traversing one-half the tubes, and returning through the remainder. The ends of these tubes are expanded into two headers, the outer header being bolted against a packed joint on the outer end of the intercooler body, while the other header, inside the intercooler body, is free to move with the expansion or contraction of the tubes. Suitable baffle-plates, in the interior of the body, are so arranged that the air, in flowing through it, will be compelled to pass three times across the tubes, thus insuring a thorough cooling effect. By removing the bolts securing the outer header, the whole nest of tubes with the headers, may be withdrawn from the base or shell for inspection or repair. Both headers have removable covers which give access to the ends of the tubes for the removal of sediment or for the insertion of new tubes when necessary.

The crankshaft bearings, crank and crosshead pins and crosshead guides of both high- and low-pressure members, are supplied with steam lubrication. From the main oil reservoir, in the bottom of the horizontal main frame, underneath the crankshaft, a small plunger pump, driven from connections attached to the air valve-gear, and with all of its working parts submerged in oil, delivers oil to a reservoir at the top of a standpipe, high enough to insure the delivery to the highest point at which lubrication is needed. From this reservoir oil flows to the points specified. The amount of oil flowing to each point is regulated by adjustable sight-feed connections. The pump is designed to pump an amount of oil greater than maximum requirements, and the excess from the overhead reservoir is returned by an overflow to the main reservoir in the horizontal frame. After the oil has passed through the various bearings, it flows back to the main reservoir to be used again. The air cylinder and rolling inlet valves are oiled from a separate five-feed positive oil pump of special design, driven from the air valve-gear. Each feed may be regulated separately.

The rate of feed of oil, to all points lubricated, may be observed by the operator from the engine-room floor. All working joints in the air valve-gear are lubricated with grease cups. The outboard bearing supporting the end of the crankshaft is independently lubricated by a supply of oil contained in a well underneath the bearing to which it is delivered by ring oilers.

The water circulation for the cylinders and intercooler has but one inlet and one outlet. Entering at the bottom of the low-pressure cylinder, water passes thence through the intercooler and high-pressure cylinder, leaving the latter at the top. This arrangement provides a positive circulation, with no danger of entrapping air in the water spaces.

An unloading valve can be provided for cutting off the supply of air to the compressor, when the receiver pressure has reached the desired limit. It is attached to the main inlet opening on the low-pressure cylinder, and is of the total closure pattern. This apparatus consists of a double-beat valve, placed on the air-inlet duct, and controlled by air pressure from the air receiver. The valve is set to shut off all the incoming air from the compressor,

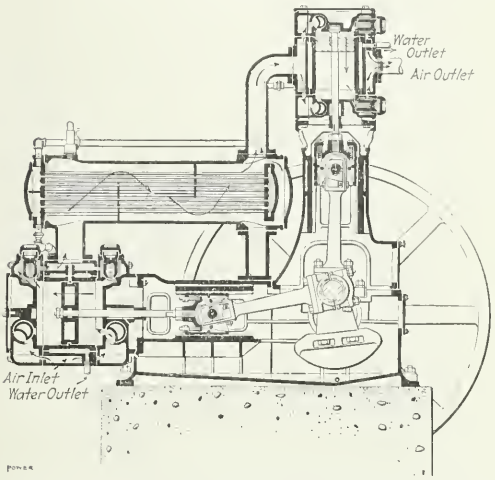


Fig. 3. Section through the Angle-Compound Air Compressor

when the receiver pressure rises above a point; that is, when the demand for air drops away. The compressor then runs under no load, except friction, compressing no air, and reducing the consumption of power to a very low factor.

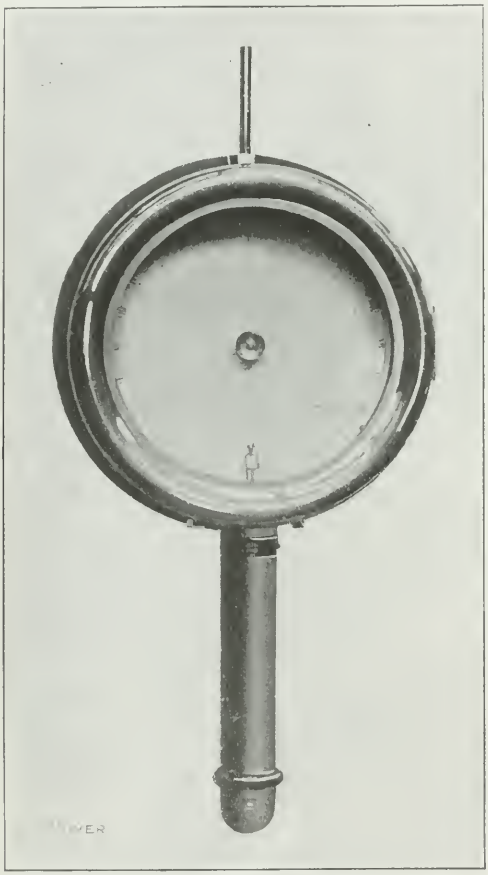
When the demand for air begins once more, that is, when the pressure in the receiver falls below the point at which the unloading device is set to act, the valve again opens fully, and the compressor automatically resumes its entire load, until the demand for air again ceases, when the cycle of operation, just described, is repeated.

This unloading valve may be adjusted by means of a weight, lever and springs, to maintain any desired pressure in the air receiver. Its action is prompt and positive, and it does not throttle or wire-draw the air in its passage to the intake cylinder. The passage is either fully open or tightly closed. At the same time, the action of this device is gradual and smooth, so that the load is thrown on evenly, without sudden shocks and consequent fluctuations and peaks in the power-consumption line.

This air compressor, manufactured by the Sullivan Machinery Co., Peoples Gas Bldg., Chicago, Ill., should be especially attractive to power plants for all sorts of manufacturing service, on account of the small floor space which it occupies, its simplicity, high overall efficiency, low factors of care, attention and repair, and flexibility of the driving element.

Uehling Vacuum Recorder

The Uehling vacuum recorder is an instrument of hydrostatic type. The pen is actuated by a float resting on mercury contained in a cylindrical float chamber, secured to the lower side of the clock case. Connected with this chamber is a steel tube of the proper length to contain a column of mercury to balance the atmospheric pressure.



Uehling Vacuum Recorder

The cross-sectional areas of the float chamber and pressure tube are such that the pen moves over the full width of the available chart for the range of vacuum to be recorded.

The Uehling Instrument Co., Passaic, N. J., makes these recorders for three ranges, viz., from 0-30, 20-30 and 25-30 in. The advantage of this is evident since a very open scale is obtained where the readings are of importance.

The illustration shows a vacuum recorder with a range from 20-30 in. of mercury.

Influence of Soot on Boiler Economy

By H. D. Fisher

The writer has been engaged in boiler-plant work for a number of years, and has made a careful study of the accumulation of soot and methods for removing it, also its effects, both by boiler tests and inspections of boilers, when they were out of service, on which various methods of cleaning were used.

Recently the writer ran tests on a boiler equipped with a tube-blowing device to determine its effect on boiler economy. The water-tube boiler was 400 hp. capacity, 21 ft. wide by 9 ft. high, 4-in. by 18-ft. tubes, three 36-in. by 20-ft. 2-in. drums and a superheater with 439 sq.ft. of surface. It was hand fired with a mixture of Pennsylvania bituminous coal and screenings in the proportion of about one to three, on a rocking grate 12 ft. wide by 7 ft. 4 in. long, or 88 sq.ft. area. Test *A* was run one week after the tubes had been thoroughly swept and the boiler operated as usual without blowing or cleaning the tubes in any way. Test *B* was run two weeks after the test *A* and one week after the tubes had been swept, the boiler being operated as usual and the tubes blown daily. The tests were of two-hour duration and were started and stopped by the alternate method.

Number of Test	A	B
Steam pressure gage, lb.	130	131
Temperature feed water, deg.	208	193
Temperature gases leaving boiler, deg. F.	437	420
Temperature superheated steam, deg. F.	424	435
Draft at boiler damper, in. water	0.50	0.46
Weight coal as fired, lb.	13,207	14,604
Per cent. moisture in coal	2.74	1.54
Total ash and refuse, lb.	2835	3558
Coal per sq.ft. grate per hr., lb.	15.0	16.6
Total water fed to boiler, lb.	111,419	121,499
Water evaporated per lb. coal, lb.	8.43	8.32
Per cent. rated horsepower developed	88	98
Heating value of coal per lb.	13,057	13,410
Efficiency of boiler grate, per cent	67.9	66.7
Loss due to latent heat of water, per cent	2.3	2.2
Loss in products of combustion, per cent	6.9	7.2
Loss in air excess, per cent	6.3	7.2
Loss due to unburned carbon monoxide, per cent	0.6	1.2
Loss due to unburned carbon in ashpit	6.7	5.3
Radiation and unaccounted losses	9.3	10.2
	100.0	100.0

Neither from these tests nor the continuous operating results of the plant could any improvement in operating results be noted.

A particularly bad feature of all forms of soot-blowing apparatus which require a number of pipes piercing the boiler side walls, especially if they are installed after the boiler setting is erected, is the cracking up of the brickwork and the amount of air leakage this allows. In some tests on 302-hp. water-tube boilers with hand-fired, flat grates, burning a mixture of two parts Pocahontas to one part screenings, it was found, from gas samples taken over the fire in the first pass, that there was 11.6 per cent. CO_2, corresponding to 77 per cent. excess air, while in the back connection simultaneous samples showed only 5.8 per cent. CO_2, corresponding to 280 per cent. excess air, or that more cold air was leaking in through the boiler walls than was coming up through the grate; they were operating a part of the boiler as an air-cooled condenser.

The worst feature, however, of all forms of fixed-jet apparatus is that they cannot be spaced close enough to effectively clean the tubes. The fine yellow dust and ash which carries over from the grate, coheres very strongly and requires a strong jet at a short distance from the nozzle to remove it.

Some large horizontal baffled water-tube boilers in one of the big Philadelphia electric-generating stations have a most elaborate system of fixed steam jets, but in practice it has been found that these will do little more than keep the soot from accumulating in large heaps in the corners of the baffles and keep the soot off the adjacent rows of tubes.

Blowing tubes with a hand pipe is usually ineffective, as the alleys are too narrow to allow a long enough pipe to reach clear across the boiler tubes, not to mention its awkwardness. One case showed this very clearly. A 508-hp. water-tube boiler, 18 ft. wide by 14 ft. high, equipped with a stoker 11 ft. wide and 12 grates long was being used for making competitive tests of semi-bituminous coals. The same man fired all the tests which were run at about the same boiler horsepower, but it was noticed that, although the tubes were blown every day, the flue temperature kept steadily increasing.

The tests were started with the boiler practically new and, owing to alterations in the rest of the boiler plant, it was impossible to take it out of service for about three months, during which time the flue temperature, with the boiler running very close to rating, rose from about 450 to 600 deg. F.

When the boiler was finally cut out of the line it was found that about one-third of the boiler nearest the inner wall was almost solid with a fine, yellow ash and a thorough sweeping brought down over a ton of it. In this case the alley was too narrow to use more than a 6-ft. pipe.

A very effective scheme in cases like this is that used by one of the large New York companies. The blowing pipe is made of two lengths which will conveniently work in the alley, joined by a swing joint, similar to those used in gas jets. The pipe is first entered with the joint bent at right angles, when this first portion of the tubes has been thoroughly covered, the joint is straightened and the back tubes can then be reached.

The general opinion seems to be, among large steam users, that while blowing tubes will help to a certain extent the only satisfactory way to keep the fire side of boilers clean is to take them out of service every so often and brush down all soot and ash off the tubes. This is even a meaner job than blowing tubes, but does not have to be done so often, and can be done with a cheaper grade of labor.

Care in this direction is amply repaid, for, with good firing, a reduction of 50 deg. F. in the flue temperature will mean a saving of 3 per cent. in the coal bill and where firing is poorer and correspondingly larger quantities of air are passing up the stack the savings will be even larger.

It is along this line and that of keeping brickwork, etc., in good condition and free from air leaks that the average engineer can do most to increase the efficiency of his plant, as they require no elaborate testing outfit, but can be seen and remedied by any man who is willing to take the trouble.

Condenser-Tube Corrosion—II

Comparison of Practical and Laboratory Results

The agreement between the two methods of work is striking. In both, the order in which the tubes resist dezincification at elevated temperatures has been found to be precisely the same. It is unfortunate that no strictly quantitative expression can be obtained to represent the relative merit of the tubes as regards resistance to dezincification. In the case of the experiment with the condenser plant the authors have been obliged to rely upon mere inspection of the tubes. Nevertheless, there can be no doubt that the 70: 29: 1 and 70: 28: 2 tubes are more resistant than the 70: 30 brass, and this more than the Muntz metal.

The supreme importance of temperature, which had been clearly indicated by the laboratory work, was amply confirmed by the large-scale test In each of the four sets of three tubes the topmost was the most severely attacked, and a study of the details of the construction of the condenser will show clearly that the top tube must have been the most highly heated of each set. On the other hand, the bottom tubes of each set must have been subjected to a distinctly lower temperature than the others, and as a result the bottom tubes in two cases have not been attacked at all, and in the other two cases the attack is less than that in the case of the higher tubes. Both sets of tests bring out the fact that the locality in which dezincification occurs is not determined by the electrochemical action of carbon or any other foreign particles settling on the tubes. It is due to a chemical action which becomes the more pronounced as the temperature is raised from the ordinary temperature to 122 deg. F., and probably higher, though the Admiralty tube must possibly be excepted from this statement. This action takes place under conditions which exclude the possibility of the settling on the tubes of any substance not derived directly from the tubes themselves.

Dezincification appears to be a phenomenon inherent in alloys of the brass type, and to be more pronounced the higher the percentage of zinc in the alloy. It starts at certain points on the tubes and spreads outward from them, until, in time, the whole tube would become dezincified. A distinct relation has been found between the presence of firmly adherent oxychloride and the spots or areas of dezincification. It has been observed in tubes corroded under conditions of practical work, as well as in the experimental condenser test. Direct evidence has been obtained in the laboratory as to the evil effect of this substance. The authors believe it to be both a result and an accelerating cause of dezincification.

The Protection of Condenser Tubes

The methods in use for the protection of condenser tubes are electro-chemical in nature; they depend either on the use of some metal, such as zinc, iron, or aluminum or its alloys, which is electro-positive to brass, and which will consequently set up an electrical current when both are connected together and immersed in sea water; or on the use of a dynamo to pass the current to the brass. In principle the two methods are identical—namely, that of making brass which it is desired to protect, a cathode at which there will be a tendency for the liberation of hydrogen, while oxygen will tend to be set free at the anode. This anode may consist of any of the metals mentioned above. The idea is to concentrate corrosion on the anode, which is sacrificed to protect the cathode.

The metal zinc has been largely employed for anodes, both for the protection of boilers and condensers. In the case of the latter, it is placed in the water-ends and is securely bolted to the tube plates. At first sight it would appear to be a more suitable metal than iron, since it is more electro-positive, but in practice this does not prove to be the case. There appear to be two reasons for this. The first is that the zinc gradually becomes covered with a fairly adherent layer of oxide, which itself is electro-negative to brass, and is a poor conductor of electricity. Thus the protective action of the zinc soon ceases, and might even be reversed but for the poor conducting properties of the oxide. The second reason is that the consumption of zinc is found to be great- far greater than that demanded by the requirements of electro-

chemical protection. It seems probable that the zinc is subject to auto-corrosion due to the action of the zinc-oxychloride which adheres to the metal.

For the protection of condensers zinc has been largely replaced by iron, which is not only cheaper, but more efficacious. The iron is used generally in the form of slabs, which are placed in the water-ends of the condenser, and are attached by bolts to the tube-plates.

If any electro-chemical action is to occur, it is obviously necessary to insure that the connection between the iron slabs and the tube-plate be thoroughly satisfactory. It is, of course, possible that the mere presence of iron slabs in the water-ends of a condenser might give rise to a certain amount of protection by depriving the water of a large proportion of its oxygen, which will go to form rust. If this be so, no special care need be taken to insure satisfactory electrical connections. To test this point, the following experiments were made:

Three pieces of 70:30 brass tube were taken, together with three pieces of wrought iron. On to one tube and one piece of iron lengths of copper wire were soldered. These were weighed separately, and then the copper wires were connected together, so as to insure good electrical contact, yet they could be separated again for weighing purposes. The tube and iron were then immersed in a beaker containing 1½ liters of sea water. One of the other pieces of brass tube was weighed, and suspended in another beaker at a depth of 2 in. from the surface. At a distance of ½ in. above it a weighed piece of wrought iron was arranged. Thus there was no electrical connection between them. The other length of tube and iron strip were similarly immersed in a third beaker through which a stream of air was kept bubbling. The air was introduced at the bottom of the beaker. All the beakers were then placed in a thermostat at 122 deg. F. The object of carrying out the experiments at this temperature instead of at the laboratory temperature, was to ascertain whether electro-chemical protection would prevent selective corrosion, which is particularly active at this temperature. At the end of seven and 14 days all the pieces of metal were weighed. The tube which was in electrical contact with the iron was completely protected, and showed no loss of weight. The surface appeared quite bright and unoxidized, and no sign of pitting could be seen, although previous experiments show that it occurs normally in seven days at this temperature. On close examination the protected brass tube was found to be covered with a uniform thin transparent layer of some substance which could only be removed by scraping. The layer was of about the thickness of tissue paper, and proved to consist of calcium carbonate. The role of this layer evidently deserves careful consideration in any discussion on the mechanism of protection.

Electrical Contact Necessary for Protection

Neither of the other tubes was completely protected, proving that electrical contact is necessary. The question then arises, how can electrical contact protect parts of the tubes remote from the contact, i.e., why does not all the current generated pass between the iron anode and the part of the tube near it?

It is difficult to see how iron slabs in the water-ends can protect the middle of the condenser.

The same difficulty is met with in considering the mode of protection by a current generated by a dynamo, as in the Cumberland process. Of course, in this case a much larger current can be used, and it can be increased at will until it is effective, but the authors have been informed by Mr. Cumberland that in normal cases 2 amp. per 1000 sq.ft. of tube surface is sufficient for protection, and where such a small average current is used the amount conveyed by the most remote foot of tube must be small. It seems certain that some other factor must operate to assist protection.

To test the matter the following experiment was made: In a glass vessel three 70:30 boiler tubes were placed at varying distances from an iron anode, the distances being ½ in., 10 in. and 20 in. respectively, but as the last was twice the area of the first, it should receive one-twentieth the protective current, or what the middle of a condenser tube should receive.

At the end of three weeks the tubes were examined. Each was covered with a thin translucent layer of calcium carbonate. Under this the brass was found to be unattacked. A fourth test piece not connected was found greatly attacked, and without any protective coating. It becomes evident that when iron anodes are used for protection, that the greater part of the protective current passes at first by the shortest path and protects only the parts near the iron. These soon become covered with calcium carbonate, greatly increasing the local resistance, and the current passes to more remote parts, and covers them with the carbonate film, which thus gradually creeps along the tube. The extreme distance over which protection can be extended is conditioned by the relative resistance of the calcium-carbonate layer, and the increasing resistance of the more remote water circuits. The part played by this film in electro-chemical protection must be immensely important.

How Electro-Chemical Protection May Be Destroyed

Electro-chemical protection may cease to be effective through: Breakdown in the electrical connections; by mechanical injury to the calcium-carbonate layer by cleaning rods, etc.; by failure of the calcium carbonate to adhere to tubes already oxidized, corroded or dirty.

It becomes clear from this experimental work that dezincification, followed by pitting, is a phenomenon inherent in brass alloys of the type discussed.

The conditions for its appearance are the presence of certain kinds of water, of which natural sea-water was one, and of a certain temperature. Dezincification may be prevented, or at least postponed, by four different methods: (1) By using a suitable water-supply; (2) by using an alloy different from brass; (3) by adjustment of the temperature conditions when brass is used; (4) by electro-chemical protection.

In the mercantile marine (1) can never be employed, and it can rarely be used even in land installation. Moreover, there is as yet no precise information as to the kinds of water which will not give rise to dezincification. As regards (2), little information is at present available. An obvious suggestion is to lower the amount of zinc present in the alloy, and thus to diminish the tendency toward dezincification. As to how far, if at all, the elimination of zinc could be usefully carried, the authors cannot make any definite statement. It is, however, certain that a complete removal of zinc would give rise to serious trouble of another kind. Possibly there may be some alloy intermediate between 70:30 brass and pure copper which would be more resistant to corrosion than either, though whether it could be satisfactorily drawn into tubes is another matter. Probably manufacturers have already experimented privately along these lines, and information on the subject would be welcomed.

A number of alloys which contain no zinc suggest themselves as suitable for the manufacture of condenser-tubes. Phosphor-bronze has been proposed on a number of occasions. It can be drawn into tubes of good quality, and at first sight would appear to be an excellent material for the purpose. Under certain conditions, however, it appears to be subject to a peculiar and deeply penetrating form of complete corrosion, the cause of which has not yet been ascertained by the authors, and the phenomenon of "detinning" has also been observed. More work upon this alloy is desirable before it can be recommended for use. A copper-nickel alloy produced on a large scale in America, and known as "monel metal," has been used for condenser tubes. It appears to give satisfactory results as far as resistance to corrosion is concerned, but its high price has prevented its extended use. [This seems to contradict the Edison Illuminating Companies' results, previously mentioned.—Editor]. The work of Carpenter and Edwards would suggest the use of a copper aluminum alloy if it could be easily and cheaply drawn into tubes, but the authors have never had an opportunity of experimenting with tubes of such material.

As regards the immediate future, and pending future investigations on different types of alloy, the best means at the disposal of engineers for hindering corrosion appear to be: (1) The entire abandonment of the use of plain 70:30 brass and its replacement by either the Admiralty alloy, 70:29:1 (tin), or Muntz's special brass, 70:28:2 (lead); (2) careful control of the temperature in condensers; (3) the extended use of electro-chemical protection. The authors consider that the importance of temperature in determining the nature of

the corrosive attack on brass by sea-water has not received from engineers the attention it deserves.

The temperature of the water in a condenser can be kept down in the following ways: (1) By limiting the amount of steam condensed; (2) by shortening the path of the water through the condenser; (3) by increasing the speed of the water; (4) by preventing choking of the tubes, either by fitting screens or filters, or by frequent cleaning. The amount of steam condensed has been considered hitherto from the point of view of engine efficiency and space economy, and not at all from the corrosion standpoint. Nevertheless, it is a fact that, within the practical limits of temperature, the greater the amount of steam condensed the greater will be the tendency to selective corrosion, and if the condenser be really overloaded this form of corrosion may go on at an extremely rapid rate.

The practice of dividing a condenser into two "nests" is a distinct aid to corrosion. As the water passes through the lower nest it becomes heated, and consequently the top nest is supplied with water that is already warm and will become still more highly heated. From the corrosion point of view it would be preferable to introduce a separate water inlet and outlet to each nest of the condenser, and to discontinue the practice of building them in nests. The speeds of water through the condensers in the mercantile marine vary between 240 ft. and 360 ft. per minute. The average is about 290 ft. per min. The speed of the water used in the experimental plant was abont 275 ft. per min. The faster the speed of the water in the condenser the lower the temperature, other things being equal, and the less the liability to the choking of tubes. In the authors' opinion the speed should be kept up at least to the highest figure mentioned above, and it might be worth while to try still higher speeds if the tubes frequently choke.

Inquiries made by the authors have shown that choked tubes are sometimes severely corroded, and sometimes not at all. If a choked tube be found in the bottom part of the condenser working normally it will not usually be corroded, since its temperature, even in this case, is still low; if, however, the condenser is being overloaded, as shown by the high temperature of the outlet water, it may be severely corroded. If a choked tube be found in the top part, however, it will usually show severe dezincification, owing to the high temperature to which it has been heated. Hitherto the corrosion of choked tubes has been attributed to the electro-chemical action of particles, more particularly of carbon, but this view has now been clearly shown to be untenable.

(Note—In the above abstract many of the statements appear merely categorical, which are in reality not so. Space considerations have dictated the omission of many of the committees' arguments. Those who wish to read the report in full are referred to the transactions of the Institute of Metals, or to "The Engineer," Sept. 5, 1913, p. 263; Sept. 12, 1913, p. 287; Oct. 4, 1913, and "Engineering," Aug. 30, 1913, p. 302, and Sept. 5, 1913, p. 339.)

Brazilian Power Station

Work continues on the port of Pernambuco improvements started about three years ago by the Société de Construction du Port de Pernambuco, says a consular report.

The jetties are being extended, the river dredged, and about one-half mile of the quays completed. A large suction dredge is rapidly filling in the space between the outer wall of the quays and the shore. This entire work, which will cost about $16,000,000, is expected to be completed within two years.

A concession for a new electric tramway and lighting system in Pernambuco was granted about 18 months ago to Dodsworth & Co., of Rio de Janeiro. This Brazilian company has made arrangements with J. G. White & Co., of New York and London, an English and American firm, to do the construction work. The foundation for the power house is being built and surveys made for the car barns and track, a portion of which has already been laid. The power machinery and rails are all of American manufacture. The power plant, when completed, will generate 4000 hp. The work is expected to be finished within one year.

Allen Friction Wrench

The accompanying illustrations, Figs. 1 and 2, show the Allen friction wrench in detail. The wrench consists of three working parts, so designed that it instantly

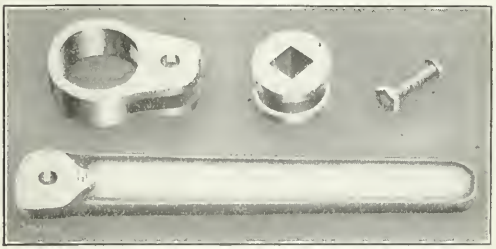


Fig. 1

Fig. 2

Fig. 3

grips the socket head, and turns it by friction alone. It is reversible, and can be used for left-hand work as well as for right. Fig. 3 shows the wrench applied for drilling purposes. It is manufactured by the Allen Wrench & Tool Co., 754 Eddy St., Providence, R. I.

A Two-Cent Rate—For the purpose of increasing the day load of the municipally owned Jacksonville, Fla., electric-light plant, the electrical committee of the board of bond trustees has authorized a straight cooking and heating rate of two cents per kw. hour. This means for Jacksonville what is supposed to be very close to the lowest rate charged for electric current for this purpose of any city in the country and it will attract widespread attention. That the Knoxville plant is owned by the city will probably be used everywhere as a convincing argument in favor of municipally owned electric plants. The new rate will prove a real factor in reducing the present high cost of living. Recognized experts state that this low rate will supply the necessary fuel for cooking at an average of less than 40 cents per person per month. Indirectly, by increasing the day load of the plant, it will help materially in adding to the city's net profits which last year exceeded $350,000. For a long time ways and means for increasing this day load have been seriously considered.

ELECTRICAL DEPARTMENT

Don'ts for Electricians

By H. M. Nichols

Don't use open fuses.
—— handle moving belts.
—— use rotten belts.
—— neglect storage batteries.
—— overfuse circuits.
—— allow belts to slip.
—— throw water on burning oil.
—— use acid salts in soldering.
—— leave joints without soldering.
—— put too much tension on brushes.
—— put water on hot bearings.
—— use emery cloth on brushes or commutators.
—— fail to replace cracked insulators.
—— step over, under, or through, moving belts.
—— strip the threads on foundation bolts.
—— use pliers with uninsulated handles.
—— burn the insulation on wires, when soldering joints.
—— burn contacts on knife switches, by opening them slowly.
—— hang clothing or other material on wiring.
—— use high-potential leads that are not properly insulated.
—— leave tools lying near a motor or generator.
—— expose electrical machinery or apparatus to moisture.
—— use lubricating oil in transformers.
—— use oil, in transformers, which has been exposed to moisture.
—— put a motor or generator on a shaky foundation.
—— run a booster without a speed-limiting device.
—— install an outdoor circuit without a lightning arrester.
—— do wiring without consulting the underwriters' rules.
—— try to save wire by freak layout of circuits.
—— leave loose or dirty contacts on switchboards.
—— forget the value of sand in fighting electrical fires.
—— meddle with circuits you are not familiar with.
—— run motors and generators without inspecting the bearings occasionally.
—— put up wiring without the proper fuses or circuit-breakers.
—— attempt to adjust series arc lamps with the current on.
—— start a motor without making sure that the field circuit is all right.
—— run a motor with a weak field.
—— make adjustments on motors and generators when they are running, this applies particularly to brushes.
—— bring a motor up to full speed too quickly when starting.
—— send a new man on a job which he does not thoroughly understand; it is dangerous for all concerned.
—— cut the blades on knife switches by adjusting the contacts too tightly.
—— block up the space in front of switchboards so that the switches cannot be reached immediately.
—— do high-potential testing, without first erecting red danger signs.
—— get your face over commutators, as there is always danger of a flash over.
—— handle meters roughly.
—— expose your watch to heavy currents, if you expect it to keep good time.
—— fail to read regularly at least one good engineering paper.
—— run a motor or generator until the windings get hot enough to smoke.
—— operate transformers without having the secondary windings grounded.
—— discharge storage batteries too low, and don't let them stand when discharged.
—— install conduit without grounding it.
—— leave packing boxes and other inflammable materials in the power house.
—— burn the contact buttons on starting boxes.
—— use brushes that are not properly fitted.
—— use both hands when working on live apparatus.
—— leave joints without taping.
—— fail to have a wiring diagram attached to each switchboard.
—— run a belt with the tight side on top.
—— run a motor or generator with a loose pulley.
—— use pulleys or couplings having exposed setscrews or bolts.
—— neglect to fence in all exposed belts and shafting.
—— allow dirt and oil to collect on the windings of motors and generators.
—— use the back of switchboards as clothes racks.
—— fail to treat every wire as though it were alive until you have determined otherwise.
—— stop a motor without seeing that the rheostat arm falls back to the starting position.
—— lean against machines or switchboards.
—— open a main feeder switch, under full load, except in the case of an emergency.
—— fail to renew the oil occasionally in the bearings of motors and generators.
—— use a rigid coupling where a flexible one can be used.
—— connect alternating-current generators in parallel without first being sure they are in synchronism.
—— run a motor or generator with loose polepieces.
—— fail to ground lightning arresters.
—— spill oil on the floor.
—— store gasoline for blow torches in the power station.
—— handle the blow torch carelessly around inflammable materials.
—— neglect to remove temporary wiring.
—— use copper wire to replace blown fuses.

—— use plugs, for series arc switchboards having defective handles or frayed leads.

—— forget that 500 volts, or less, is sometimes fatal.

—— run a motor or generator which is vibrating badly.

—— couple two machines together without making sure that the alignment is perfect.

—— start a new motor for the first time without making sure that the armature turns freely.

—— install rheostats and other sources of heat without separating them from inflammable materials.

—— use wooden switchboards.

—— drive nails where there is danger of their coming in contact with concealed wiring.

—— put telephone or other signal wires above power wires.

—— cut open a cable and leave it exposed to moisture.

—— stop a motor by releasing the starting rheostat arm, without having first opened the main switch.

—— cut the strands in skinning the insulation from lamp cord.

—— throw a switch unless you know positively to what circuit it is connected.

—— leave oily waste in any place except metal waste cans.

—— fail to use the proper size starting rheostats for motors.

—— allow a single-phase induction motor to run on the starting winding.

—— neglect to run down grounds, and remedy them as soon as they show up on the ground detector.

—— start a series motor without first making sure that it is properly loaded, to hold down the speed.

—— forget that there is danger of injury from short-circuits on low-tension wiring, when tools are handled carelessly around bare contacts.

—— fail to consult the nameplates on motors and generators and make sure of having the proper voltage, before putting them in service.

—— start a motor by throwing in the main switch, without first seeing that the starting rheostat arm is in the off position.

—— connect different makes of transformers in parallel without first making sure that the polarity is the same in both.

—— open the field switch on a generator with the resistance all cut out of the control rheostat.

—— forget that there is always a possibility of low-voltage wires becoming dangerous, by accidental contact with high-voltage wires.

❖

Overhauling a Railway Storage Battery

By Ben Dawson

In an electric-railway power plant with which the writer is connected, there is a storage battery consisting of 272 cells; each cell contains 15 plates, eight negative and seven positives. The cells are arranged in four double rows of 34 each, which brings all the cross-over connections at one end of the battery. The cells are connected by a permanent pure lead busbar, which necessitates burning all the plate lugs to the busbar. The battery is the Planté type.

Recently it became necessary to clean 136 cells, also to install new positive plates in all the cells that were cleaned. Since the battery is used to help out on the railway load and for lighting the power house and car barn after the cars are all in for the night, the writer had to adopt the sectional method of overhauling the battery, so as to least interfere with normal service conditions.

Sections of 12, 11 and 10 cells were worked on according to the position and finishing of each double row of cells. A ⅜-in. hole was drilled in the busbars that comprised the terminals of each section, and to these were fastened a dipped, soldered, copper angle busbar to which were connected the discharging cables, section-jumper cable and initial charging cables. One section was completely overhauled before commencing on another; the section first being discharged through a grid resistance switch and series-type ammeter, as shown in Fig. 1.

When the discharging current had reached a low point, the discharging cables were taken from the section ter-

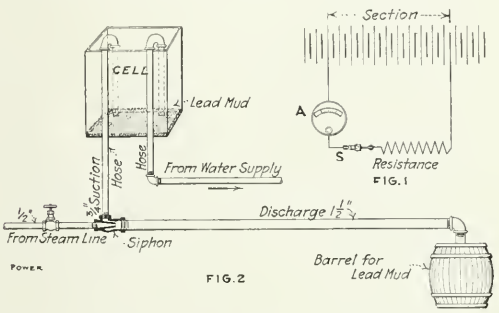


Fig. 1. Discharging Section
Fig. 2. Steam-Siphon Method of Cleaning Cells

minals. The section-jumper cable was connected to the section terminals, and all the positive-plate lugs in one cell in the section were severed near the busbar with a lug cutter. This opened the section circuit as well as the whole battery. All the positive plates in the section were then cut from the busbars, taken out of the cells and placed in a plate wagon and hauled out of the battery room. The old separators were also taken out of the cells and discarded.

Some of the old acid was saved and used in the hydrogen-gas generator, to make gas for burning the new positive plates. The negative plates were scraped with a thin, flat, wooden stick to remove all surplus loose, spongy lead. The positive sides of the lead busbars were filed with a roughing file to aid in lead burning the new plates to them. All the cells were cleaned by means of a steam siphon and fresh water supplied from a tank on top of the power house. The steam-siphon method of cleaning out the lead mud of the cells is shown in Fig. 2. In this case approximately 130 lb. steam pressure was used.

The purpose of the barrel was to collect all the lead mud, and holes were drilled near the top to allow the water to drain away and the greater part of the lead mud settled to the bottom of the barrel. There was a plentiful supply of fresh water and a pressure sufficient to stir up the lead mud in the cells. The hose that connected with the siphon was ¾-in. rubber steam hose,

and of sufficient length to reach the bottom of all the cells in the section. The water hose was also of rubber to withstand the action of the acid. After all the lead mud and old acid had been cleaned out, the negative plates were left covered with fresh water over night and siphoned out the next morning.

The new positive plates were brushed off with a clean, soft brush to remove surplus loose lead peroxide and dust previous to their insertion in the cells. After the positive plates had been properly spaced, oiled mild steel sub-burning bars were placed under the lead busbars and over cross-cell wooden supporting blocks in preparation for lead burning the positive-plate lugs. A special self-closing burning tong sub-burning bar, and plate lug were used for burning in the plates with hydrogen gas from a standard-type gas generator, and air pressure supplied from a pump and tank. After all the positive plates of the section had been burned, enough all-wood separators were made up to finish a section; these were thoroughly washed with fresh water, and allowed to drain before being inserted between the plates in the cells.

During the process of putting in the separators, care was taken to keep all dowels in line, starting with the first separator between the first and second plates nearest the body, and using a good strong wood stick to properly space and straighten the plates as the separators were being put in the cells. When all the separators of the section were in place, the section-cable jumper was taken off and new chemically pure sulphuric acid of 1.220 specific gravity was put in the cells sufficient to cover all the plates about one-half inch. The battery terminals were disconnected and the initial charging cables connected to the section terminals, and the overhauled section put on its initial charge.

A moderately high rate of charging was employed in this case, owing to the limited time and conditions, but the initial charge was not stopped until the specific gravity of all the cells in the section had maintained the same readings for several hours, and the plates were in a safe condition to be put into active service. At this juncture the charging cables were taken off, and the battery terminals connected so that the whole battery was ready for night service. The rest of the sections were treated similarly.

CORRESPONDENCE

High Voltage

Mr. Stockwell's letter in the Nov. 11 issue relative to trouble with the voltage of an alternator is not specific enough. He mentions that the plant has three alternating-current generators and that two of these machines show a voltage of 2300 volts while the third registers 2350 volts. He does not state, however, whether or not the machines were operating in parallel when this condition existed.

If they are in parallel on the same busbars, slowing down, or attempting to do so, on one machine only reduces the load taken by that one machine and transfers it to the other two. This increase of load on the two machines and decrease on the third, tends to slow down the heavily loaded machines, and speed up the lightly loaded machine. This action will tend to bring the machines into equilibrium and all three machines will run at the same speed, regardless of the setting of the individual governors.

Mr. Stockwell mentions that there is a Terrill regulator on the system. If the machine with the higher voltage is on the busbars to which the regulator is connected, changing the speed or the field current, within certain limits will not affect the voltage, as the Terrill regulator tends to keep the voltage constant at a certain value, for which the regulator is adjusted.

With the machines in parallel the adjustment of the rheostat after it is once set, should not be tampered with, as this affects only the power factor of the individual machine, causing it to take a heavy, lagging, wattless current. Adjustment of the governor of the machine affects the load as carried by this machine.

I think that Mr. Stockwell will find that either the voltmeter-transformer ratio of the one machine is different from the ratio of the transformers on the other two machines, or that his voltmeters need recalibration. There is also a chance that the resistance of the leads connecting the transformers of the 2300-volt machines to the voltmeter may be great enough to make this difference. Two or three volts drop in these leads would be sufficient to make a 50-volt difference on the voltmeter scale.

JAMES M. PURCELL.

Richmond, Va.

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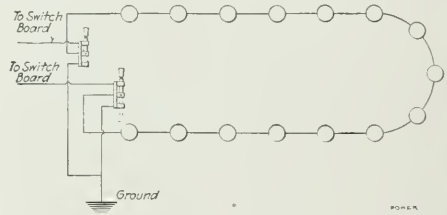
Protecting the Lineman

The sketch shown herewith is of an arrangement of switches put in the plant to protect the lineman while trimming the arc lamps. Each side of each circuit that leads out of the power house has a single-pole, double-throw switch in it. The top lug is connected to the wire that leads from the arc-lamp switchboard; the wire that leads out of the building to the arc-lamp circuit is connected to the middle lug and the wire that leads to the ground is connected to the bottom lug.



GROUNDING SWITCHES ON ARC-LIGHT CIRCUIT

When the lamps are in service the switches are thrown up, but when the lineman goes out to work on the line, the switches are thrown down as indicated by the dotted lines; this grounds both sides of the arc-lamp circuit.

This arrangement protects the lineman from any shock either static or high tension. Should the arc-circuit line be crossed with another line the current will pass to the ground through the ground switch and the man trimming the arc lamp will not be injured.

We use two switches on each circuit, so that if the arc-lamp circuit should be open at any place each side would be protected by the ground.

Yazoo City, Miss. A. G. VINSON.

GAS POWER DEPARTMENT

New Process of Cleaning Producer Gas

A decidedly novel method of cleaning producer gas is described in a paper by H. F. Smith, of Lexington, Ohio, which was presented at the annual meeting of the American Society of Mechanical Engineers.

Referring to the illustration, the raw producer gas on leaving the producer is first cooled to a point where the tar vapors are condensed by being passed through a primary cooler or condenser. From this the gas is carried into an ordinary rotary gas pump *B* which delivers the gas under pressure into the main *C*; it is then delivered through a porous diaphragm *E* and discharged from there into the main *F*. A sump or separator *G* is provided in which the tar accumulates.

The structure of the diaphragm *E* is of considerable importance, for the successful carrying out of this process and the materials used seem to have an important bearing on the operation of the equipment. The diaphragm must be sufficiently porous to permit the gas and tar to pass freely; otherwise it will soon become blocked with deposits from the gas and fail to operate. Many materials may be used for this purpose, but at present spun glass is preferred. The density of the diaphragm can be regulated by the quantity of glass used and by the degree of compression maintained between the metal screens. Ordinarily, the thickness of this diaphragm is about ¼ in. The diameter must be adjusted in accordance with the quantity of gas to be treated. Ordinarily about 400 cu.ft. per hr. can be handled for each square inch of diaphragm area.

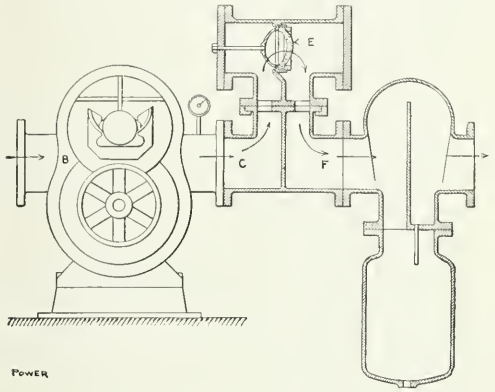
In passing the diaphragm an important change in the physical state of the tar occurs. On the entering side the tar exists in a large number of minute particles, ordinarily known as tar fog. In passing the diaphragm these particles are caused to coalesce so that on the discharge side the tar particles are relatively large, so large in fact that they can no longer be carried forward in the gas current and immediately separate out by gravity. All that is necessary for the complete separation of the tar from the gas is to provide a sump, or drip, into which the precipitated tar can drain.

It appears to be possible to secure almost any desired degree of gas cleanness simply by regulating the pressure maintained across the diaphragm. In ordinary commercial operation, it is found that a difference in pressure of from 2½ to 4 lb. will give a degree of cleanness that is ample for any commercial requirement.

At low velocities the gas will pass through the porous diaphragm without any apparent alteration, and the effectiveness of cleaning is directly related to the velocity of flow. For example, the degree of cleanness produced with the velocity of flow resulting from 5 lb. pressure is very much greater than that produced by the velocity of flow resulting from 1 lb. pressure, and when the velocities are as low as those produced by a pressure of a few ounces only, there is no perceptible change in the tar content of the gas after passing through the diaphragm.

No water is used in connection with this process except that required to cool the gas; consequently there is no production of tar emulsion and the water flowing from the condenser is perfectly clear. The tar separated by this process is practically water free, and can be used for any purpose to which coal tar is adaptable.

For the maintenance of continuous operation the tar must be sufficiently fluid to pass through the porous diaphragm without creating undue resistance, and therefore it is necessary to maintain the temperature of the gas



SECTION THROUGH STATIC SCRUBBER

entering the diaphragm at a point that will reduce the viscosity of the tar to as low a point as is consistent with complete condensation of the tar vapors.

This apparatus would not be well suited for use on gas containing large quantities of lampblack or for the purification of gas from coals yielding very heavy viscous tars. For high-volatile coals, however, such as are found in Ohio, Indiana and Illinois, and for lignite, it has been found in practice to be thoroughly practical and effective.

The exact method by which this tar extractor operates has not been conclusively demonstrated. The first and most obvious theory is that the tar particles are precipitated by being brought into direct collision with the threads or filament of the porous diaphragm. That this does not constitute a complete explanation of the process is indicated by the fact that the material of which the porous diaphragm is constructed has a marked bearing on the effectiveness of the process and would indicate some action other than simple mechanical collision. For example, if the porous diaphragm is made up of steel-wool instead of glass-wool (the physical structure of the diaphragm being as nearly as possible the same in each case) the process does not operate with anything like the effectiveness secured with glass-wool diaphragms. It would seem that the possibility for collision would be the same in both cases.

It is possible that in addition to the effects of mechanical collision there may be an electrical attraction exerted by the glass fibers constituting the porous diaphragm which are located at microscopic distances from each other and which are undoubtedly subjected to some electrification from friction with the gas currents. If the possibility of such electrical action is considered, the increased effectiveness of glass as compared with steel for the construction of the porous diaphragm is satisfactorily explained. That friction of this nature is capable of producing electrical disturbances of considerable magnitude is well established.

The first commercial equipment of this kind has now been in continuous operation for approximately 18 months. This outfit is handling gas for a producer-gas power plant of approximately 1000 hp. The second commercial equipment is handling approximately 900 hp. producer gas, and has been in daily service for approximately 10 months. The largest single installation is an equipment for cleaning 200,000 cu.ft. of gas per hour.

Suction-Producer Operation

By George W. Muench

In the July 15 issue there appeared an article by the writer on lignite producer troubles, commenting on the various suction-producer troubles and their remedies. The present article gives a general outline of lignite suction-producer operation with a view to the prevention of the commoner troubles.

The producer being ready for operation, the first procedure is to start the fire. Place upon the grate a small quantity of oil-soaked waste: any old waste which is ordinarily thrown away will do for this purpose. Then on top of this waste should be placed dry shavings, small pieces of wood, or any other dry waste material that collects around a plant. This should extend to a height of about 2 ft. above the grate. If the wood contains considerable pitch, not so much need be put into the producer.

Before lighting the fire be sure that the vaporizer contains water, also that all the water seals are filled. In case the gas enters the scrubbers before escaping through the purge, the water must also be turned on the scrubbers. The purge being opened, ignite the fuel on the grate. The ash and fire-doors should now be closed; also the pipe supplying moist air from the vaporizer should be closed. The blower is now started. In some installations the centrifugal scrubber acts as a blower, drawing air through the regular air intake, and to hasten the fire it is often helpful to open the poke holes near the level of the grate.

When the wood is burning freely fill in about a foot or a foot and a half of coal. As soon as this burns freely the producer may be entirely filled with coal. The blowing should be continued for some time. If the installation has a test cock between the producer and the purge pipe the gas can be tested frequently and as soon as it burns with a blue flame without sputtering it can be led to the engine. The purge at the engine should then be opened and that at the producer closed, the gas being allowed to escape for a few minutes, so that ample time is allowed for all the apparatus between the engine and the producer to be filled with gas. There should also always be a test cock at the engine. As soon as the gas proves satisfactory here it is ready for use in the engine.

If the plant operates continuously, that is, 24 hr. per day, it is more difficult to prevent weak gas, clinkering, engine slow downs, etc., because the producer fire has to be worked with the load on the engine. When operating only part of a day, 8 or 10 hr., it may be necessary only to work the producer before starting in the morning, or better still a good working after shutting down at night, or probably both. If it should be necessary to work the fire in the mean time it might be done at the noon hour when the load is ordinarily less. To get the most efficient service the operator must perform the various operations carefully and so far as possible at equal intervals of time, and in the same regular rotation. It is hardly possible to give an operator definite directions as to what method is best suited for his plant; his experience must teach him this. Neither is it possible to tell him how much time he may safely allow for these various operations without danger of letting the gas become too weak. However, the work should always be done as rapidly as possible, as an excess of air will always affect the steady running of the engine.

One question the operator will ask himself many times is: "How can I prevent the formation of clinkers?" First of all, to prevent clinkering and to keep soft those clinkers that have formed, plenty of steam must be admitted, yet not too much, for it will cause the formation of too much hydrogen which in turn causes preignition in the engine, one of the most serious engine troubles. When operating with a clinkering coal the fire must be worked oftener, but not so hard each time. Keep the fuel moving, so as not to give the clinkers much chance to fuse to the fire-brick lining. Yet one must not work the fire too often as that will cause a waste of fuel and usually a weak gas. The removal of clinkers must not be neglected, for if they gather on the walls in large quantities it will mean hard work to get them out without drawing the fire, to say nothing of engine shutdowns. When poking from the top to loosen clinkers the new operator should always be careful not to jam holes in the fire-brick lining instead of in the clinkers. Holes in the lining are excellent places for the formation of clinkers. Having loosened the clinkers from above, work them down to the grate and remove them from below by working through the poke holes at the grate. It has been the writer's experience that the less the fire is poked from the top the better. When the producer is operating properly there is really no reason why it should be poked from the top and if rocking grates are installed there need be no poking from below except when troubled with clinkers. Do not disturb the fire any more than necessary, and the result will be economical operation.

Ashes can be removed from the ashpit whenever the operator finds time. Remove the ashes as rapidly as possible, to prevent much air from entering through the ash door. Of course, when the ashpit consists of a water seal the removal of ashes is made easier, because no air can enter providing the seal is kept filled while raking out the ashes.

Directions for producer cleaning sometimes recommend first filling the producer with fresh fuel. In the writer's opinion this is not best, for clinkers, if present, are harder to work through the bed after charging. Also if holes have been formed, the fresh fuel, especially if pea size, will find its way into the lower zones and into the ash and will be removed from the grate before being

thoroughly burned. By working the fire first and getting it into good condition and then adding the fresh fuel it need not be disturbed again. Of course, enough fresh fuel should always be present to supply the necessary amount of gas. In case the fuel bed is exceptionally low it may be well to add some fresh coal before working the fire and then finish charging the fire after having worked the producer.

The lignite producer trouble most feared is tar. With present-day washing apparatus, however, there need be little tar trouble. If the installation is what it should be it is up to the operator to get clean gas at the engine. With a down-draft producer the gas washers need not be of the same degree of efficiency as with the updraft, as much of the volatile matter gases in the hot zone of the fuel bed.

About two gallons of water per horsepower per hour is the least that should be used for thoroughly cleaning the gas. The speed of rotary washers is of great importance, the higher the better, and it should be at least 1000 r.p.m. The writer recalls a plant where tar was causing trouble. By increasing the speed of the centrifugal washer from 900 to 1250 r.p.m., the trouble was remedied. Centrifugal washers are equipped with screens, and broken screens often cause inefficient operation of the washer.

When a plant is operated only during the daytime and shut down every night some operations necessary for putting the plant in condition for the night are of importance. The engine is stopped by closing the gas valve and opening the switch in the ignition circuit. Immediately the purge at the engine should be opened to provide an escape for the gas, as the gas continues to be formed in the producer for a short time after the engine has been shut down. Next open the purge at the producer and shut off the air and steam; shut off the water supply to the scrubbers. Experience will soon tell the operator how much opening of the air valve on the producer is necessary for sufficient draft to keep the fire alive over night, yet not cause waste of fuel. Having worked the fire, removed the ashes and charged the producer, the plant is ready for the night. The engine requires no attention other than shutting off the cooling water and oil. It is also well to put the engine in starting position, so all will be ready in the morning.

To start the next morning remove the ashes from the grate; if necessary work the fire and charge the producer. Having started the blower turn the water on the scrubbers. Blow up the fire for a few minutes and purge at the engine until ready for use.

It becomes necessary occasionally to clean the scrubbers and pipe lines. The doors on the scrubbers should be opened to allow the gas to escape; this may take an hour or more; then the coke or laths, whichever is used, may be removed. When replacing the coke after having cleaned the scrubber, care should be taken not to break it. The coke in the bottom of the scrubber should be from 3 to 4 in. in size, and at the top not smaller than 1½ to 2 in.

Many plants are now using centrifugal washers. Steam can be used to good advantage for cleaning a centrifugal washer, and the screens in this type must be kept clean to insure its efficient operation.

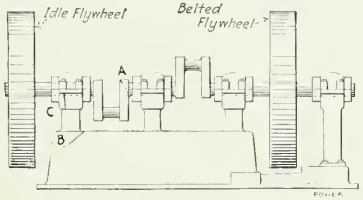
If properly installed the pipes can be readily cleaned without removing any sections. All bends should have tees or crosses with blank flanges. By removing these blank flanges the pipes can be cleaned very readily. Also steam, if it is to be had, comes in very handy for thinning the tar in pipes, and with a slight dip toward the producer much of the tar will run out and thus save considerable labor.

It is always well to attend to all cleaning in the daytime, so that it will not be necessary to use a light, as more or less gas may be in the apparatus and cause an explosion. It is also advisable to have more than one person present while cleaning is being done. The operator should always bear in mind that the gas is very poisonous and if breathed in any quantity will cause violent headaches, and sometimes unconsciousness or even death.

Broken Crankshaft

The accompanying sketch shows how the crankshaft of a two-cylinder gas engine was broken in a small electric-light plant near here. This is a mixed plant consisting of a 100-hp. steam turbine direct-connected to a 75-kw. generator and an 85-hp. gas engine belted to a 50-kw. generator.

The gas engine was running on very light load, in fact, almost idle, as it was Sunday morning. The engineer had just stepped out into the boiler room when he



Crankshaft, Showing Location of Fractures

heard a heavy pounding in the engine room, and rushing in saw the idle flywheel on the gas engine wabbling. He displayed presence of mind in shutting down the engine as he had to pass directly in the path of the flywheel in doing so, and a few more revolutions would undoubtedly have caused it to part company with the engine with disastrous results.

An investigation showed the shaft to be broken off as indicated at *A*; the bedplate was cracked in two places, at *B* and *C*. Both cracks and the break in the shaft were new.

The cause of the accident is not known, although it is possible that the bearings were out of line, caused by bearing No. 1 getting hot at some previous time and some of the babbitt being wiped out.

M. W. Utz.

Minster, Ohio.

Displaces Steam—It is stated on good authority that a 70-foot all-steel gasoline electric car, costing approximately $40,000, has been put in operation between Jackson and Columbia, Mississippi, by the New Orleans & Great Northern R.R. and made its first trip recently, displacing the steam train that has heretofore run over that road. The car in question has a seating capacity of 85 people, and a 11-ft. compartment for baggage. The manufacturers guarantee that it will make 60 miles an hour hauling two trailers. It is said that this is the first gasoline electric car ever put into service by a Mississippi railroad.

REFRIGERATION DEPARTMENT

Setting Expansion Valves

By Thomas G. Thurston

Setting the expansion valves on a large system with a number of valves is the most important part of the refrigerating engineer's daily routine. This is especially true in a direct-expansion system.

In setting the expansion valves two factors are to be considered; the expansion coils and the machine working on them. To secure maximum efficiency from the expansion coils the whole length of the coils should be used for evaporation. Whatever portion of the coils is used for superheating the vapor after it has been evaporated is of little use as far as refrigerating effect is concerned. This can be readily seen when one remembers that it takes, at 15 lb. suction pressure, approximately 572 heat units to evaporate 1 lb. of liquid, while one heat unit will raise the temperature of 1 lb. of vapor approximately 2 deg. As the temperature difference between the evaporating ammonia and the outside of the coil is seldom over 15 or 20 deg., it will only take from 8 to 10 heat units to bring the temperature of the vapor up to the outside temperature. Also, while the temperature range, and consequently the rate of heat transmission is gradually decreasing while the gas is being superheated, it remains constant and maximum while the liquid is being evaporated.

It is of prime importance then to have the whole length of the coil in contact with ammonia liquid or wet vapor. If more liquid is fed to the coil than can be evaporated it makes no particular difference as far as the coil is concerned, it would simply escape from the end of the coil into the suction line. This, however, would more than likely cause disaster at the machine. Taking the machine and coils both in consideration the maximum capacity is obtained if the vapor leaves the coils in a saturated state with no entrained liquid. In this case the coils will work at maximum efficiency, there will be little heat taken up while the vapor is passing through the suction line from the coils to the compressor, and the vapor will arrive at the machine in a condition favorable for most efficient operation. If the vapor should be superheated before leaving the coils, it will superheat more in the suction line. The vapor will expand and less ammonia will be handled per stroke of the compressor, thus cutting down its capacity. On the other hand, if liquid ammonia is carried with the suction vapor from the coils, it will evaporate either in the suction line or in the machine, without doing useful work in the refrigerator, and the efficiency of the plant is cut down.

The problem is then to set the expansion valves so that the coils will get all the liquid they will evaporate and no more. This is not so hard to determine where a cooler with a single-expansion valve is used and thermometers are placed in the suction line to the compressor. The expansion valve is adjusted until the suction vapor is 1 or 2 deg. higher in temperature than the saturated vapor at the suction pressure at which the machine is operated.

When the valves and coils are multiplied the trouble begins. How is the operator going to determine when each coil is getting just what it will evaporate and no more? This is a hard problem and is never mastered until the operator is thoroughly familiar with the peculiarities of each individual expansion valve. An expansion valve is seldom opened more than from a quarter to half a turn of the wheel. Now a quarter of a turn on a valve with quite a little lost motion will probably only crack it off the seat. If the valve has no loose connections it will open it quite a little. Again, the condition of the valve and seat may make a difference.

In most of the older plants the engineer judges the working of the system by the frost on the machine. Taking this point alone into consideration may be misleading as a thermometer in the suction line when there are a number of expansion valves. It is possible to get the proper temperature of vapor or the right frost at the machine with only a few out of a number of coils working properly. To illustrate I can remember one case where we were running three machines together on four different brine tanks. As the frost began to come off the machines I went over and opened up the expansion valves on the two nearest tanks which seemed to be a little short of ammonia. When I came back to the engine room I was surprised to find the frost leaving the machines at a still greater rate than before. I looked at the thermometer in the suction line of one of the machines and found the temperature had risen about 10 deg. I hurried back to the tanks and opened the valves a little more without results. The next time I opened the valves quite a little more and I found the temperature of the gas coming down, but I still had to open up a little more to get them just right.

Another case was that of a small machine running on a direct-expansion system in a number of freezers. The first day I operated this machine it nearly drove me wild. I kept trotting between the freezers and the engine room nearly all day. The machine started to get a little too cold to begin with so I went up to the freezers and shut off the expansion valves a little. When I came back to the engine room the head pressure was nearly up to where the relief valves would blow and the machine was just as cold as ever. In my anxiety to get the head pressure down I hurried back to the freezers and opened a few of the expansion valves quite a little. When I came back to the engine room I found the head pressure down and the machine warming up. It was not long before the machine was running too warm, so back I went to the freezers and opened the valves a little more. This made matters worse, so I had to repeat the performance. This happened several times during the day.

The trouble in both cases was the same. Some of the valves had been opened too much and some not enough. In the first case I had opened the valves too much on two of the tanks and not enough on the other. The net

result was satisfactory as far as suction-gas temperature and the frost on the machine was concerned, the extra amount fed through the valves on two of the tanks cooling the superheated gas from the other two tanks to the proper temperature.

In the second case, with the direct-expansion machine, the valves were open very little and foreign matter would clog them. When the valves clogged the liquid naturally crowed through, the valves remaining open, and one or two of these most likely had been opened too wide in the first place. The result was that the machine froze up. When I shut off the valves still more it simply aggravated matters, because this cut down the flow through all the valves remaining clear, running up the head pressure and forcing a still larger proportion through the valve that was open widest. On the next trial I happened to open the valves that were clogged. This reduced the head pressure, cut down the feed on the coils causing the trouble and the superheated gas from the coils on which I had just opened the valves neutralized whatever excess was fed through the other coils.

In both of these cases I had overlooked two important points, the suction pressure and the appearance of the suction valves on each individual coil. In either case the suction pressure would have been below normal, and the suction valves on the coils getting too much liquid would be frosting heavily while those that were not getting enough would show little frost or most likely be thawing off.

The suction pressure in connection with the temperature of the suction gas or frost on the machine is one of the best indications of the working of the system, but gives no basis on which to judge of the working of the individual coils. This can be determined only by observation, study and experiment. The sound made by the liquid passing through the expansion valve, the appearance of the frost on the expansion and suction valves, the appearance of the coils themselves in direct-expansion work, with the temperature variation as indicated by the thermometers, where the coils are working in separate rooms, are all good indications of the working of the coils. If an expansion valve sounds "dead" or gives no sound and the corresponding suction valve is thawing off, it will be known that the feed is stopped on the coil. If the expansion valve sounds all right, but the suction valve is thawing off while all the others are frosted it indicates too light a feed on the one valve. If in a freezer it is found that the temperature has gone up or has remained stationary when no additional stock has been stored, the coil is not getting as much ammonia as it should and the expansion valve should be opened wider. The action of a coil can be judged approximately by the way a moistened finger sticks to it. If the whole length of the coil is evaporating liquid ammonia the finger will stick all the way along to the suction valve. If only a small part of the coil is evaporating liquid there will be quite a little difference between the way the finger sticks at the part in which the liquid evaporates and where only vapor is in contact with the coil. Along the vapor section most likely the finger will not stick at all, this depending on the temperature of the room.

On the other hand, if the machine starts to freeze up and it is found that one room has dropped several degrees while the others have remained normal, and it is evident that the coil is evaporating liquid all the way to the suction valve, this coil is without doubt the cause of the trouble, and the feed should be checked accordingly. Sometimes, however, it is necessary to experiment with several expansion valves before locating the trouble.

Care should be taken not to open the expansion valves too wide. This can be done when the system is short of ammonia. In such a case vapor blows through with the liquid. This is indicated by the frost disappearing from the expansion valves, and if the valves are opened still more the expansion valves, liquid header and sometimes the liquid line for quite a distance will all become frosted. The obvious remedy is to charge more ammonia into the system, but if this cannot be done at the time, the expansion valves should be closed enough to remove the frost on the high-pressure side of the valves.

One point to remember is, that the valves at the end of the liquid header farthest from the supply will feed faster than those nearer to it, especially if the header is long, the supply at one end and the ammonia feeding through fast. This is due to the velocity of the moving volume of liquid and also to the fact that the valves nearest the supply will get most of the vapor carried with the liquid. Consequently, these valves must generally be opened more to feed the same amount of liquid as those farther back.

For the best economy carry the highest suction pressure possible, with the proper temperature of the suction vapor. To determine this, experiment with the expansion valves, noticing the effect on the suction-gas temperature of each individual valve. When the proper point is found for the existing conditions, the suction-pressure gage and the suction-gas thermometer or the frost on the machine will indicate any defective working of the coils.

Pipe-Line Refrigeration

With the recent advancement that has been made along refrigerating lines it appears that the subject of pipe-line refrigeration has not received the attention that it deserves. Though in use for a number of years in some of the large cities in the United States, such installations are more or less foreign to the average refrigerating engineer. Nearly every city or hamlet in the country has its ice plant and a desirable location for a new installation is difficult to find. There is, however, an unlimited field for pipe lines and if pushed in the future like ice plants in the present and past, there would be a vast amount of work for all builders of refrigerating machinery. On the above subject, G. F. Bein read an interesting paper before the Third International Congress of Refrigeration. His experience and, therefore, his remarks were limited to the direct-expansion system.

One of the principal annoyances appears to be the excessive use of ammonia. No matter how carefully the line was watched the ammonia would get away. In the five years that Mr. Bein served as master mechanic and superintendent of the system an average of about 20,000 lb. of ammonia per year was used. During this time, there had been several accidents. Twice there was a rupture in the line and once the baffles in the cooling tower let go and crashed through the roof and on top of the ammonia condensers. As nearly as could be estimated at the time the loss of the ammonia in each case amounted to about $4000. Under regular operating con-

ditions probably from 16,000 to 17,000 lb. of ammonia were used per year. This is probably not excessive, considering the length of the mains, as there were between three and four miles of trunk lines and a mile or more of laterals.

Large losses are apt to occur as the mains are all underground in a conduit and a leak is hard to locate. There is more or less water in the conduit in low places which acts as a natural absorber of ammonia and even after the leak is stopped the weak solution of aqua gives up a strong odor.

The greatest trouble usually exists in the manholes, where the valves and expansion joints are located. Any material change in pressure or temperature due to a shutdown or heavy frosting out will usually start a number of leaks. The danger of fire, particularly if it occurs at night, is always a source of trouble. Every customer has a stop box at the curb, where it is possible to shut off the ammonia, but at times the fire has a good start before it is discovered and a falling wall may rupture a line and, perhaps, waste the greatest part of the charge.

A condition seldom met with in any other refrigerating system is the highly superheated condition of the return vapor. This is governed by the climatic conditions. In hot weather the return vapor will rise to 75 and 80 deg., owing to the temperature of the ground. From mercury wells placed in the lines regular readings were taken and it was found that when the return gas was most highly superheated, the best work was being done on the line.

The theory advanced for the heavy ammonia losses was the decomposition of the high-temperature gas, but if such is the case it would be interesting to know what becomes of the foreign gas, for seldom, if ever, was there any purging. In the opinion of Mr. Bein the line losses amounted to about 50 per cent., but, on the other hand, there was a decided gain on the outgoing liquor, as it usually left the plant at from 90 to 95 deg., but was delivered at the expansion valves at 75 to 80 deg., or about ground temperature.

Another annoyance is the meddlesome customer, who usually thinks that if a little is good, more is better, and frequently helps himself to a few full turns of the expansion valve. This was obviated by taking the handling of the valves out of the customers' hands and protecting the wheels with lock shields.

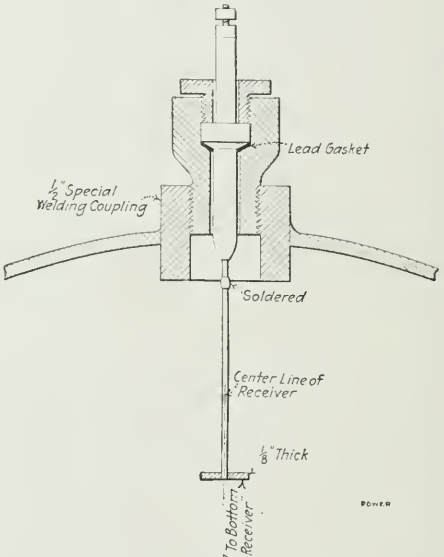
Several creameries were operated on the brine system, and the good satisfaction these systems gave led to a consideration of a pipe-line system operated with brine. Then, at least, there would be some chance to detect the leaks and stop the losses. The brine system, however, also has its objectionable features, as there is a loss both coming and going, while on the direct-expansion system, as already stated, there is a material gain on the liquor leaving the plant. It also requires cumbersome auxiliaries in the form of circulating pumps; but this is more than offset by the fact that all of the ammonia is under immediate control at the power plant, and that the storage of outsiders' goods, as well as the opening of doors or burning of lights is recorded on 24-hr. charts.

One of the great advantages of the brine system would be the ease with which connections could be made into the mains for new or prospective customers. In the first place the entire system should be in the form of a loop, then by closing the valves at the street intersections, the connections could be made with scarcely any loss of brine, while in the direct system it often requires a half day to pump out, and then if the valves are leaky or the system is more or less foul with oil, it cannot be fully accomplished and connections are often made under partial pressure. The result can be readily imagined.

The question of fixing rates and insulation together with the above troubles are the principal objectionable features connected with pipe-line refrigeration, and if they can in a measure be overcome, there is no reason why nearly every city of any size cannot add refrigeration to its other utilities.

Electric-Pump Control for Liquid Receiver

In a certain cold-storage plant there is an ammonia separator in the main suction line, so that no liquid can get into the compressor. The liquid from this separator is drained into a receiver made of 15-in. pipe 6 ft. long.



Spark Plug as Insulated Electric Contact for Liquid Receiver

An electrically operated pump was desired so that when the liquid in the receiver reached a certain level the pump would operate and pump the liquid into the main receiver where the pressure was 185 lb. as against 15 lb. in the receiver placed in the suction line. The conditions required a contact wire that would be insulated from the receiver and extend down into the receiver so that when the liquid had risen to a certain point the liquid, contact wire, and the iron receiver itself would make a closed circuit. As a means to this end I utilized the ordinary automobile spark plug shown in the sketch as being the simplest, cheapest and most satisfactory method. This arrangement operated through a solenoid switch which cut in the pump motor.

Robert S. Wheaton.

Milwaukee, Wis.

EDITORIALS

Conservation of Water Powers

Gifford Pinchot and his followers in the conservation movement demand that there shall be no perpetual grants of power sites, and that the government shall, by regulation of rates and charges, share in the profits of all power plants built on navigable streams or in the public domain. Opponents of this policy assert that such restriction and regulation will drive capital away from investment in water-power enterprises. The "Pinchotites" regard the tendency toward private monopoly of water power as a serious menace, which if uncontrolled is likely to make the whole country under tribute to a water-power trust. The opponents scoff at the menace of monopoly, and say that development of water power to save coal and other fuel, is of higher importance than the matter of regulating rates or preventing monopoly.

The Pinchot faction points to the growth of water-power development under the Forest Service's strict regulation, as proof of their contention that their policy does not discourage capital from investment, and they seem to have the best of the facts, the financial reports generally indicating that water-power enterprises are paying larger returns to investors than railroads, utilities and industrial undertakings. There is also pertinency in the suggestion that the holding by ten large large groups of water-power interests of three and half million horse-power undeveloped, while they have developed less than half that amount, indicates that the difficulty is not in restriction of grants, but in nondevelopment of powers already granted.

It is inevitable that sooner or later Congress must give more careful attention to the water-power question than it has yet received, and must decide upon a definite policy, not subject to the whims of cabinet officers or the discretion of public officials.

It is not at all likely that the nation will agree to turn over these national resources and properties to state control and disposition. The history of the wasteful and careless handling of natural resources when they have become the football of state politics, is not such as to encourage giving them more plunder from the national resources. It is not likely, either, that there will be a return to the granting of perpetual grants or franchises for water powers.

If the criticisms of the antis prove valid, and capital will not seek investment under limited franchises and regulation of rates and capitalization, that problem will be solved when we come to it. Possibly it may be found wise for the government to develop its water powers in the public interest, as the nation has reclaimed millions of acres of the arid lands of the West without profit.

There is as yet, however, nothing to indicate that capital is fighting shy of water-power enterprises, even under strict regulation. In fact, as with railroad regulation, there is a growing sentiment among cautious investors in favor of enterprises where Uncle Sam guarantees careful supervision of the manner in which the money is spent and the business is conducted, even if it does not promise as large returns as did the old system of unrestricted exploitation.

Closely following the split in the National Conservation Congress, the House of Representatives is asked to investigate the charge that under a perpetual franchise and state regulation, the building of the great Mississippi River power plant at Keokuk has done nothing to benefit the consumers or the public. It is charged that the rates made by the company are as high as the cost of steam power, and in some instances higher, and that the contract made with the city of St. Louis alone, taking but a small part of the output of the plant, will yield sufficient return to pay five per cent. on the company's total investment.

Record Keeping

One of the important duties of an editor of this paper is to visit power plants for the purpose of obtaining first-hand information on actual operating conditions. These visits reveal, among many other things, a lack of record keeping of plant performances that is astonishing in view of all that has been said and shown to emphasize the importance of the practice. And this paucity of recorded information is not confined to small plants. It exists in plants where the opposite conditions would be expected.

Then, too, plants are found where the multiplicity of record and report forms would bewilder a confirmed systematizer. Often this condition is temporary, for it proves difficult in practice to arrive at the most suitable forms without having come to them by the adoption and elimination of numerous others. The condition is then excusable.

In some plants where the management insists on a division of costs for power as delivered to the various departments, for convenience the total cost is apportioned equally among the departments. Sometimes this may be permissible, but often it is ludicrous, as, for instance, in a department store, where the shoe department is charged with as much refrigeration as the kitchen or fur department. If costs are to be divided among departments at all, it would be worth while to investigate so that the charge may be accurate and equitable. If then it should be desired to ascertain the cost of power or the power consumption per unit of product from a particular department it will not be necessary to guess. Where an attempt at completeness in cost keeping is made, accuracy should be paramount, and usually it is not easy to be accurate.

Some engineers who have installed complete cost-keeping systems in their plants obtain estimates from the local power companies as to what they would furnish light and power for, and then put the difference—when the lower cost is in favor of the plant—in a sinking fund to offset the depreciation charge. This is truly good engineering.

A well kept system of record and cost keeping will do more than anything else toward whipping an old plant into shape or keeping a new plant in proper condition, if the engineer and manager are eager to apply the knowledge gained by the revelations of the system.

It is indeed to be regretted that in so many plants record and cost keeping are so grossly neglected when they are so badly needed. It is to their reproach that this can be truly said of power-plant engineers.

The Locomobile Principle

The most efficient use of steam in a heat engine is exemplified by the locomobile, which, on believable tests, has produced a horsepower-hour on less than eight pounds of steam, and the Ferranti turbine, for which a performance of seven pounds of steam per brake horsepower-hour, is reported.

The feature common to both of these is superheat of high degree, and repeated application. In the locomobile the steam is highly superheated as it goes to the high-pressure cylinder, is reheated by passing through another superheater on its way to the low-pressure cylinder, and both cylinders are bathed continuously in flue gases hotter than the steam which they contain. In the Ferranti turbine the steam, initially superheated to some seven hundred degrees Fahrenheit, surrounds the high-pressure barrel tending to keep up the superheat during expansion, and as it passes from the high- to the low-pressure section, the steam is reheated to the original temperature, and surrounds the low-pressure barrel at that same high temperature, so that the working steam which would otherwise be cooled by expansion below the point of saturation, actually goes to the condenser, or to the feed-water heater which precedes it, in a superheated condition.

The reheating feature, while it could be effected by high-temperature steam brought from a distance, suggests the proximity of the boiler and the motor which it supplies, and we are quite likely to see the locomobile principle used upon a larger scale. The capacity of the unit need not be restricted to that of an engine or turbine which a boiler will carry upon its back, nor to that of a shell boiler. There is no reason why a good-sized engine or turbine should not be placed in the locomobile relation to its boiler or boilers, which may be of the water-tube type hung to the same structure which carries the prime mover.

"Editions" and "Impressions"

Do you know the difference between "editions" and "impressions" in book-buying parlance?

As the difference has been much misunderstood by many readers of technical and engineering books, and as the publishers themselves have discussed the use and misuse of these terms in their trade press, we take this opportunity of making clear that difference. Let us assume that you bought an engineering book five years ago and that the title page bore this line: "Third Edition—1908." Then, recently, you discover a later "edition" bearing the line: "Fifth Edition—1913," and you conclude that your old book is out of date.

You buy the new book, and on its comparison with the 1908 edition you find that, beyond a few plate corrections and a change of date on the title page, there is no difference between them. Then you say things!

What you really bought was a new "impression"—a reprint of an exhausted third edition. While the publisher may not have intended to practice a willful deception, his book is really sailing under false colors, and you are ready to believe that the publisher has preyed upon your credibility, to say the least.

While the idea is so new to many, for several years it has been our practice, or that of the McGraw-Hill Book Co., to retain the date on the title page of a book from its first publication until it was thoroughly revised, and calling the reprints "impressions," not editions, as "First Edition, Second Impression."

Altering the date, it is claimed by some publishers, prevents the purchaser from "fearing that the book is too old," and thus lessens its sale. Changing the title-page date will not make an old edition new any more than would a new nameplate make over an old engine.

An experienced book buyer will invariably look at the copyright date before purchasing and verify the publisher's claim that he, the buyer, is getting a new "edition," not a new "impression."

It is to be hoped that a standard practice will soon be fixed by all reputable publishers, thereby insuring the purchaser that their books bear no evidence of fraudulency and that their title pages prove a true bill. In the meantime, watch the copyright date if you are seeking a new edition rather than a new impression.

What is the committee of the American Society of Mechanical Engineers appointed to urge the establishment of an industrial museum going to do about it?

According to Secretary Daniels, the navy has used during the past year thirty million gallons of fuel oil. At present, however, only a small proportion of the warships in service, the later battleships and destroyers, are equipped to burn oil, but practically all the vessels now building will be thus equipped. When it is recalled that the government is paying over twice as much for oil as it did in 1911, the probable extent of Uncle Sam's oil bill in the near future is apparent. Secretary Daniels urges, as a step toward economy, that the government refine its own oil from its petroleum in the Elk Hills and Buena Vista fields of California and thus be independent of market prices.

Another attempt is to be made to reorganize the Portsmouth Coal Co., which is itself a company reorganized from the old Rhode Island Coal Co. Hayden, Stone & Co. now hold the property as security for an unpaid mortgage of $80,000. The present proposal is to form a new company with a capitalization of 1,000,000 shares of the par value of $1 each, and to ask the present shareholders to buy the new stock at par.

There are extensive deposits in Rhode Island and southern Massachusetts of a hard graphitic coal. Many attempts have been made to mine it commercially, but never with permanent success. The coal will burn all right under proper conditions, and has a fuel value which ought to warrant its mining. We hope that the next attempt will be allowed to rest upon its own basis of facts, and that no attempt will be made to boost it up with such a nostrum as Williams' catalytic treatment which was an unfortunate feature of the last attempt.

READERS WITH SOMETHING TO SAY

Experience with Boiler Graphite

I have been reading with interest the articles that have appeared in POWER from time to time relative to the use of graphite as a scale preventive and remover. In the plant where I am employed the use of graphite was prohibited, as it was tried in one of the company's other plants and the results were far from satisfactory as the graphite carried over and clogged the cylinder drains, etc. This, I believe, was due to a poor grade of graphite, excessive foaming and overload.

About a year ago our boilers became so badly scaled that it was necessary to retube them. After this was done I received permission to paint the shell with graphite. On Dec. 11 and 16 I graphited and cut in boilers Nos. 4 and 5. The graphite in No. 4 was rubbed on dry and the results obtained were not as satisfactory as in No. 5, as the graphite used in this boiler was mixed with water to make a fine paste and applied with a brush, afterward being rubbed to a glossy finish. The boilers were cut out Jan. 7, being in active service 22 and 27 days respectively, being 2 and 7 days overtime as our service-time limit on boilers was 20 days. After the boilers were cooled down and washed out we were astonished to find only a fine gray powder on the sheets. This powder could be brushed off with a cloth and the graphite was still on the sheet. This was surprising as in the past it took four days to chip the scale from the bottom sheets.

I consider one should be very careful in the use of graphite in old and badly scaled boilers, and blow them down frequently and do not try to run too long before finding out what action the graphite has on the scale as the scale falling from the tubes forms a solid mass on the sheet and if the boiler is not blown down in time to remove this, a badly bagged sheet will be the result. Some time ago an engineer told me of the use of graphite mixed with white shellac. I would like to hear from some reader of POWER who has tried it.

C. R. VAN KEUREN.

Famosa, Calif.

Your Son's Vocation

The question of a son's vocation, brought up in the editorial in the Oct. 28 issue, is all important. The first requirement is a good education. By the time the son has finished high school he will be old enough to and should decide what he wishes to make his life work. It is the father's duty to acquaint the son with his trade, enough for the boy to determine whether he wishes to follow it or not, be it engineering, carpentering, doctoring or what not. Many successful engineers came from the farm with no other machinery to cultivate their bent for engineering than a passing locomotive or a thrashing machine. As far back as I can trace on both sides of the house there was only one engineer, and he was a backwoods sawmill man. From him I got my first inspiration, and I find very little interest in other than mechanical things. I am an engineer because I like the work and for no other reason.

When my two sons have an education, I shall advise them to look about and see what trade or vocation they prefer, and when that is done I shall urge them to get the proper training to make a success of it no matter what the trade is so long as it is honorable. The man that is not well versed in his vocation will not be a success, and in seeing others advance above him will think he has chosen unwisely, and his sons will receive little or no encouragement to follow his lead.

Many young men are prone to choose a clerical or office line of work because it is clean and looks easy when in reality they would be better off physically, mentally and financially in an engine room or foundry or some other place where the work was neither easy nor clean, and will worry along through life just around the corner from the poor house.

Regardless of what the son does choose as a life work he should be encouraged to make himself as proficient as possible in that line.

J. C. HAWKINS.

Hyattsville, Md.

Horsepower and the Power of the Horse

I have read with interest your editorial on page 574 of the Oct. 21 issue on "The Origin of the Term Horsepower as Applied to Mechanical Work." I think that for the benefit of the younger engineers who may read this article a little additional explanation may be of interest.

While it is true that reliable experiments have shown that the continuous work of a horse is more accurately shown to be 22,000 instead of 33,000 foot-pounds, the fact remains that in most cases the load is carried in one direction only; the return trip being made light, and in many cases the distance hauled is comparatively short. This being the case, authorities as quoted by Haswell show that the work of a horse will be from four to five or six times the normal rate.

To illustrate: A few years ago the company of which the writer was chief engineer received an order for a small haulage machine. The specifications were taken from our catalog and called for the smallest size listed. The request for information regarding the work to be done by this machine failed to bring the desired information; in fact, their statement in substance was that they knew what they wanted and if we did not care to furnish it, doubtless someone else would. The order was accordingly filled and a few months later we received a letter stating that there was something wrong with our machine. They wrote that they had purchased a 12-hp. machine, but it would not do the same work that had been previously done by three mules. Further corre-

evidence brought out the fact that these mules were hauling coal cars up a short grade and returning cars empty; in addition, of course, the engine had increased the hauling speed and the output, so that the work they desired required a 25-hp. engine.

This illustrates very forcibly the trouble encountered by many inexperienced engineers who attempt to install mechanical in place of animal power, and I feel that the point deserves emphasis.

J. H. Stratton.

Cleveland, Ohio.

Condensate Accumulator for Turbine

Mr. Purcell's idea of using a 60-gal. tank to catch the condensate in the exhaust of a turbine as told in the Oct. 28 issue, p. 611, is simple and at the first glance would appear feasible, but I do not consider it an advisable method, although it may be cheaper than any other in first cost. In allowing the tank to fill to the exhaust pipe before draining, there is danger of water-hammer in the exhaust pipe in two ways. One is, that at the proper time for draining the tank the attention of the attendant might be called to something more serious for the time being, or it might possibly be forgotten, which would allow the water to back up into the exhaust pipe and cause water-hammer. The other reason is that the height of the water cannot be seen until it reaches the danger point, and should the tank be nearly full, and the turbine pull over a slug of water the tank would be no protection to the exhaust pipe. If, when draining the tank, the inlet valve was not closed before the atmospheric valve was opened, some water might be drawn into the exhaust pipe by the vacuum therein and the same conditions would be present as before. Another reason is that the arrangement takes much time for proper attention and must be very closely watched to prevent filling up as the amount of condensate is not always the same. The tank would be better if provided with a water-gage about half way on the tank and a small pump or a good trap to the 1½-in. drain pipe. This condensate is pure water without any oil or scale-forming matter, and should be returned to the feed-water heater. The arrangement he shows will do the work provided it is watched close enough and might do so for months without trouble, and yet, in five minutes it could do damage enough to pay for the cost of a reliable pump or trap.

H. C. Jones.

Baltimore, Md.

Testing Fire Hose

The responsibility of testing fire hose usually devolves on the engineer in charge of an institution or building, and as the matter is becoming more important, it is believed the following hint will be of value to those on whom this duty rests.

The usual way in which fire hose is tested is by means of water and as if there were a fire. While this method has certain features which may recommend it, it has several inherent defects which make it impractical in many cases, and further opens the way to an early decay of the hose, especially as the hose is seldom dry when returned to its rack. Should the hose burst during the test, damage is sure to result which will sometimes greatly exceed that of the value of an entirely new hose. Again, a test of the hose should be made at least once a year.

The better way is to test the hose with air at, say, 100 lb. pressure. This can be done readily in many plants having air compressors. In case there is not a compressor in the plant one may be often easily procured, and if that is impractical then the next best thing is to take the hose to a place where there is a suitable compressor. The hose will leak appreciably but not abnormally. Should there be any weak spots in the hose they can be readily detected.

An advantage of air is that the hose can be handled without danger of soiling the clothes of the tester, and in case of bursting practically no damage will be done, and immediately after the test the hose can be replaced on the rack. The test can be made in almost any part of the building, and in general is as handy and desirable as could be desired.

A. P. Connor.

Washington, D. C.

Lubricating Inclosed Engines

Mr. Burmfirth, in the Sept. 16 issue, gives a description of the manner in which he cleans the oil in his inclosed-type engines. We accomplish this in a different but satisfactory manner. The engines are 250-hp., high-speed inclosed type. Each is equipped with a gravity-oiling system having a cast-iron tank of about 4 gal. capacity on the engine frame over the guides. This tank is piped to the top of the crank, main bearing, and cross-head with a feed valve in each line.

After passing over the bearings the oil is drained into the crank case and then to a cast-iron tank placed under the valve-gear, and below the level of the crank case. This receiver holds about 3 gal., and is divided into two compartments. One side is filled with water up to within ½ in. of a hole in the partition which is located about 3 in. from the top. There is a fine-mesh strainer in the top of this side through which the oil passes. This prevents particles of waste and sand from going over with the oil. The oil from the crank case runs through this strainer into the water where particles of metal, sand, dirt, etc., that are too fine to be stopped by the strainer are washed out in passing into the water, and the clean oil overflows into the other side of the tank. There is an oil pump placed in this side and operated by the valve-gear.

This pump forces the oil back through a ¼-in. pipe to the tank on top of the frame, the oil being used over again. This system holds 5 to 6 gal. of oil and 1 gal. of water in the dirty-oil receiver. We use a good grade of engine oil, and the old oil is all taken out, and new oil put in once a month. The old oil is run through a filter with a steam coil in the bottom of it, and used for valve-gears, pumps, shafting and in the crank case of the stoker and fan engines. Each of the high-speed engines uses from 5 to 6 gal. of oil per month. This is a good system of oiling except that the oil is kept too warm, and, although the oil is fed in a stream to the bearings, they run very warm. The lubrication at the end of the month seems to be as good as at the beginning when the new oil is put in, and there is very little difference in the temperature of the bearings with old or new oil. The bearings are tightened up about once in two months. The

time required to clean this oiling system is about ½ hr. per engine per month. In this system, a good grade of oil is essential. At one time a cheap grade was tried, but did not work satisfactorily, also the filtered oil was used over again, but that caused trouble from warm bearings, and it was found best to use a good grade of new oil on the engines and use the filtered oil for other purposes.

H. J. Cooper.

Annapolis, Md.

Boiler Attachments

The series of articles* on the installation and care of boiler attachments, by J. E. Terman, especially No. 3 on water columns, feed valves, etc., cannot be too highly commended. Some of his statements are open to argument, for there are some questions that never will be settled satisfactory to all engineers.

It has been my lot to fall in with some of the dangerous conditions he mentions as bad practice. In one case, all the feed valves were 2-in. globe valves, placed to close against the boiler pressure, so that they could be packed when closed, if the pump was stopped, with steam on the boiler, and no pressure on the stem packing.

On several occasions the disk of the valve between the check valve and the boiler came off the stem, and we had to pull the fires and cut out the boiler to prevent its burning; then it required some time to locate the cause of the trouble. The valves were turned around at the first opportunity.

Another trouble was with the internal feed pipes, where the water was bad and scale formed, stopping them up so badly that sometimes the pipe threads in the bushing in the head were stripped. Changing from iron to brass pipe of a larger size helped the trouble.

In another plant the water-alarm whistle blew, as the fireman supposed, for high water. After blowing down awhile, and seeing that the whistle did not stop he decided that it was low water. The glass was high up and the water level could not be easily seen. Fortunately, no damage was done. If there had been no high-water alarm there could not have been a mistake.

In one case the cylinder-head packing of a feed pump would not hold. A gage was put on the discharge pipe and when the feed regulator closed the pump pressure went up to two and one-half times the boiler pressure. The trouble was caused by a bypass around the pump governor being partly open, and was not noticed for some time.

In regard to fusible plugs, I have in mind a plant of 4000 hp. of water-tube boilers, nine boilers, and not a fusible plug in any of them. Another plant of six boilers is without plugs; another, a government plant of four boilers, is without fusible plugs, also a number of others, all in a state having a rigid boiler law.

J. C. Hawkins.

Hyattsville, Md.

Pipe Work and Fittings

It seems as if everything pertaining to engineering matters in general has been discussed in technical magazines, with the exception of pipe-fittings and pipe work, and when we come to think a little on the subject, we realize that there is room for better knowledge of fittings and general pipe work.

Send a helper for a fitting and he will probably return with something entirely useless for the work. I have had engineers come to my plant for odd fittings, when doing repair work, who could not name the proper fittings wanted. "Lemme see whatcher got" was their way out of it. Supply men find it difficult to take orders for fittings from some engineers, many having to sketch odd ones to show just what is wanted. In large plants where large assortments are kept in stock, the man in charge must certainly know his fittings to enable him to make requisition for those to be replaced.

Reduced tees, ells, couplings, etc., should be properly figured so as to have as few joints as possible in a pipe line, although but little attention is sometimes paid to neat workmanship, so long as the gas or liquid to be conveyed reaches its ultimate destination, less several per cent. of its original velocity.

Many engineers have bushed fittings to save a few minutes time, only to regret it later. When the pipe man comes for an odd fitting, do not tell him to "bush it," but take time to get what is correct. Bushings are not ornamental in pipe lines, especially in engine or boiler rooms where they are subject to the gaze of those who notice such things.

In a small plant I happened to visit some time ago, the engineer had just completed a soap-boiling arrangement which required four bushings to bring it down to the proper sizes. The odd part of it was that he had placed the order for the fittings for the job. "Took some figgerin'," he said, "to make um come out right." Such jobs look untidy and also cost more.

Go over a pipe line and observe the unnecessary joints. Don't tear the line out to remedy the trouble, but in future use only the joints that are absolutely required. An idea of properly built pipe lines can be had by examining some automatic sprinkler installation in your neighborhood, which, if well designed, will have no extra joints and the lines will be properly fastened or suspended as the case may be.

A catalog from any reputable fitting manufacturer gives the proper names for all classes of fittings, valves, hose connections, hangers, etc. One will be surprised how easily it is to get a good working knowledge of the parts, and probably order the pipe and fittings for a complete pipe line less the last length, which must be cut on the ground, owing to the difference in the amount of thread various fittings will take. Pipes threaded with new dies will enter a fitting much farther than those cut with old dies.

Second-hand fittings have caused engineers to "lose their religion" when steam was turned on a repaired line only to give an imitation of a Chinese orchestra, but these occurrences can be lessened by using a little judgment in selecting the fittings. All second-hand fittings should be closely examined when dismantling a line and again when ready to use a second time. Sound your fittings the same as tubes or flywheel, and save hours in time and lessen the leaks and danger of bursting fittings.

When a joint is unusually hard to break, what do we do? Hammer the fitting, use an oversized pipe wrench, and add a few feet of pipe to the handle for extra lever-

*See pages 461, Sept. 30; 560, Oct. 21; 618, Oct. 28; 635, Nov. 4, 1913.

ige, and yank away. Easy for you, but rather hard on the fitting. Such fittings should be carefully examined before going back to the supply room. If the pipe threads enter the fittings too far, throw it away, unless you want to do the work over.

Unions cost money, it is true, but use them when passing through places difficult to repair. Do not build a line two or three hundred feet long without unions, as a leak may occur near the center. Never make up joints dry, but use some ready-made pipe compound, graphite and oil, white or red lead, and save yourself many a cuss word when making changes in a line you never expected to take down.

FRITZ W. FISCHER.

Knoxville, Tenn.

Running Cross-Compound Engine on Light Load

Among the engineers at a recent gathering was a road man employed as an erecting engineer by a well known firm of engine builders, who related an experience met with during the last winter. He told what had to be done (and the cost thereof) to the low-pressure side of a vertical cross-compound engine that was completely wrecked, due to ice forming in the hotwell of a sufficient thickness to effectually seal the tail pipe, causing the exhaust pipe and cylinder to be filled with water when the priming pump was started.

This led to a discussion of operating compound condensing engines. Some present said it was their daily practice to run with a vacuum in the receiver on starting up and on very light loads, and could see no objection to this practice. One man stated that in his opinion it was dangerous to carry a pressure in the receiver on light loads, because the low-pressure side would be doing all the work, and the high-pressure piston might pull water up from the receiver through the exhaust valves. Others were of the opinion that the above argument might apply if the pressure in the receiver was supplied direct, as through a bypass, but that it did not hold if the receiver pressure was due to the exhaust coming from the high-pressure cylinder, as in that case the water could not back up against the pressure. Another engineer stated that it was his practice to run during the noon hour with a greatly diminished load (only a little above friction) with all drips wide open, and a vacuum in the receiver, having followed this practice for over five years without any trouble whatever. He said that the receiver was fitted with a reheating coil, supplied with steam at boiler pressure from the main line, the object of which was the reëvaporation of a greater part of the condensation.

A correspondent has recently called the attention of engineers to two articles which have appeared in POWER on the subject of water in the engine cylinder: one June 25, 1912; the other Aug. 26, 1913.

In the former article it was shown how water may come through the high-pressure cylinder and accumulate in the receiver, and become a menace to the low-pressure side by its being likely to be taken over into the cylinder.

The latter article described a series of tests made by some engineers in Belgium, during which water was purposely pumped into the steam pipe supplying the engine. The conclusions reached by these gentlemen were: That every precaution should be taken to keep the receiver well drained, notwithstanding the report that "the engine suffered not the slightest damage during the tests."

I heartily agree that it should be kept well drained, but cannot see how the ordinary trap can drain a receiver when it has no pressure to make it work, or when the cutoff is so short on the high-pressure side that there is a vacuum in the receiver as a result. Even should there be no trap, but just an ordinary pipe open to the atmosphere, it could not drain, for the atmospheric pressure would exceed the receiver pressure and keep the water in. Receivers are likely to be subjected to boiler pressure at any time. Should it contain a reheating coil, a split in the coil or a burst fitting and boiler pressure in the receiver is the result.

Should an admission valve stick open from any cause, the same result will follow.

Receivers should be tested to 50 per cent. above the highest running pressure and that is more than they would ordinarily be subjected to under running conditions. Intending purchasers of this type of engine would do well to put a clause in their specifications to this effect and see to it that it is carried out by the builder. In view of the importance of this subject, may I venture to suggest that the editors of POWER invite readers to discuss the subject, stating what is their practice in starting and running under light-load conditions with compound condensing engines?

H. ROLLINS.

Plainfield, Conn.

[We should be pleased to publish such discussion.—EDITOR.]

Testing Tightness of Cover Joint

Recently I had occasion to grind to a snug fit a cover for a small tank made of 4-in. brass pipe. After grinding in the cover until it seemed the joint was air-tight as described, I was at a loss to test the joint because I could not drill a hole in the tank to attach a gage.

I decided to blow steam into the tank and quickly put on the cover, allowing the steam to condense, thereby forming a vacuum. This was done and as the vacuum was maintained for a considerable time, I decided the joint was tight enough.

W. C. DIXON.

Hastings-on-Hudson, N. Y.

Abandoning a Boiler in Case of Fire

Referring to Fred W. Heuer's question in the Sept. 16 issue, my advice would be: Leave the pump and engine running to utilize the steam and keep the boiler supplied with water. The engine will slow down as the steam goes down. The pump will keep water supplied so there will be no danger of a boiler explosion.

The question was conditioned that the engineer had no time to draw fires. In that case he would have only time to run away and the best thing to do would be to let things run down and run for his life. If we all failed to answer as long as this the questioner could have been burned up long ago.

F. A. MATHEWS.

Clinton, Iowa.

ENGINEERS' STUDY COURSE

Trigonometry—III

Beginning with this lesson the answers to the previous lesson's study questions will be given first, before the new lesson is taken up, and, as a rule, the answers will be given more fully worked out than has been the practice heretofore. The idea of the new arrangement is that the student, starting with what is practically a review of the previous lesson, will find it easier to proceed with the extension of the subject.

Last Lesson's Answers

6. As given in the "Last Lesson's Answers," page 801, No. 1; the *sine* $A = 0.6$ which, according to the table, is between 0.5878 (sin 36 deg.) and 0.6018 (sin 37 deg.). Taking any of the other functions the angle will be found to be the same, somewhere between 36 and 37 deg., and much nearer the latter. For example, the cosecant is 1.6666, which is between 1.6616 (csc 37 deg.) and 1.7013 (csc 36 deg.). From more exact tables it could be found that the angle A is 36 deg. 52 min. 11.64 sec.

7. The hypothenuse of the right triangle involved is given as 100 ft., and the altitude as 60. The relation $sin\ A = \frac{a}{c}$ becomes $sin\ A = \frac{60}{100} = 0.6$ which as found in the last answer corresponds to an angle of practically 37 deg.

8. The sides involved are those concerned with the functions of tangent$\left(\frac{a}{b}\right)$ or cotangent$\left(\frac{b}{a}\right)$. If $a = 2b$, then $\tan A = \frac{a}{b} = \frac{2b}{b} = 2$. From the table the angle whose tangent is 2 is about 63½ deg.

9. If the side c equals 1, the other sides of the right triangle correspond directly to the sine and cosine of 30 deg., or, from the table, 0.5 and 0.866.

10. In Lesson I, the sine of an angle (forming part of a right triangle) was defined as the ratio of the opposite side to the hypothenuse, and the cosine as the ratio of the adjacent side to the hypothenuse. On these premises the sine of one of the acute angles of a right triangle is equal to the cosine of the other acute angle. This was also shown in Lesson II, and, in addition, that the sine of an angle is equal to the cosine of its complement. Then the two acute angles of a right triangle are complements, or together equal to 90 deg., and the third angle is by construction a right angle (90 deg.) so that the three angles total 180 deg. Another proof might be developed from Fig. 4, last lesson. Angles IAB and BAC were complements by construction. All that needs to be shown then to prove the proposition is that the angles IAB and ABC are equal. The sine being equal to the opposite side divided by the hypothenuse, $sin\ \angle\ IAB = \frac{DB}{AB}$ and $sin\ \angle\ ABC = \frac{AC}{AB}$ but since $AC = DB$ the sines and hence the angles are equal.

Logarithmic Functions of Angles

In many trigonometrical problems multiplication or division of functions of angles are involved. For those preferring to use logarithms for their other problems in multiplication and division, tables are constructed which give directly the logarithms of the natural numbers corresponding to the functions of angles, thus saving the necessity of looking an angle up twice or in two different tables. These logarithmic tables of trigonometrical functions are very convenient and are to be found in most handbooks and mathematical textbooks. Tables can be had carried out to degrees and fractions of degrees (minutes or even seconds). In these logarithmic tables, to avoid the numerous negative characteristics that would otherwise have to be used, the characteristic of each logarithm is increased by 10. In the natural table it can be seen how many of the numbers are less than 1. All of these would normally take logarithms having negative characteristics, but increasing them by 10 they are all made positive.

Relations between the Functions of an Angle

There are ten fundamental relations which the trigonometrical functions of any angle bear to one another. The student who would go very far with this branch of mathematics should memorize these relations until they are as familiar to him as the multiplication table.

The first of these propositions is that the square of the sine of an angle plus the square of the cosine is equal to 1. Expressed as an equation it is

$$sin^2\ A + cos^2\ A = 1 \qquad (1)$$

The diagrams, either Fig. 3 or Fig. 4, show this to be merely the old familiar proposition that the square of the hypothenuse of a right triangle is equal to the sum of the squares of the other two sides. In a right triangle where the other two sides are the sine and cosine the hypothenuse is equal to 1 and the square of 1 is 1.

The second proposition is expressed

$$Tan\ A = \frac{sin\ A}{cos\ A} \qquad (2)$$

From Lesson I and Fig. 2.

$$Sin\ A = \frac{a}{c}\quad cos\ A = \frac{b}{c}\quad tan\ A = \frac{a}{b}$$

Substituting these values

$$Tan\ A \text{ or } \frac{a}{b} = \frac{\frac{a}{c}}{\frac{b}{c}}$$

the second member of which reduces to $\frac{a}{b}$ by canceling the "c's," proving the proposition true.

In the same way the third to the sixth propositions, inclusive, may be proved as follows:

$$Cot\ A = \frac{cos\ A}{sin\ A} \qquad (3)$$

for the equivalent is

$$\frac{b}{a} = \frac{\frac{b}{c}}{\frac{a}{c}} = \frac{b}{a}$$

$$Cot\ A = \frac{1}{tan\ A} \qquad (4)$$

for $\frac{b}{a} = \frac{1}{\frac{a}{b}}$

$$Sec\ A = \frac{1}{cos\ A} \qquad (5)$$

for $\frac{c}{b} = \frac{1}{\frac{b}{c}}$

$$Csc\ A = \frac{1}{sin\ A} \qquad (6)$$

for $\frac{c}{a} = \frac{1}{\frac{a}{c}}$

The seventh and eighth propositions are similar to the first and would be proved by the right triangle $AEFA$, Fig. 3, Lesson I.

$$sec^2\ A = 1 + tan^2\ A \qquad (7)$$

$$\overline{AE}^2 = \overline{AF}^2 + \overline{EF}^2$$

for $AE = sec\ A$, $AF = 1$ and $EF = tan\ A$

$$csc^2\ A = 1 + cot^2\ A \qquad (8)$$

for $\overline{AG}^2 = \overline{AI}^2 + \overline{IG}^2$ and $AG = csc\ A$, $AI = 1$ and $IG = cot\ A$.

The ninth and tenth propositions were covered in Lesson I, namely:

$$vers\ A = 1 - cos\ A \qquad (9)$$

$$covers\ A = 1 - sin\ A \qquad (10)$$

As is evident from the fourth proposition, *the tangent and cotangent of the same angle are reciprocals of each other as are also the secant and cosine and the cosecant and sine* from propositions five and six.

Study Questions

11. Express the tangent of the angle A in terms of its cotangent. If the tangent is equal to 3, what is the cotangent?

12. Given $\tan A = \frac{4}{5}$, find the other trigonometrical functions without using the table.

13. Prove that the sine of 30 deg. equals $\frac{1}{2}$.

14. Find the other trigonometrical functions of 30 deg.

15. What is the versine of 45 deg.? Find the other functions also.

❖

Erratum: On page 801, under "Last Lesson's Answers," a multiplication sign was used by mistake for a plus sign in answer No. 2. Corrected the equation would read $c = \sqrt{a^2 + b^2} = \sqrt{24^2 + 143^2} = 145$.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

Hobble skirts and high heels were responsible for 52 accidents in October, complains the Pennsylvania R.R. Ain't them th' sore guys, Constance! Gawd knows, we has our troubles gettin' classy duds without them choochoo Johnnies a-buttin in— Hello! Yes? I gives you your number twicet, an'— What's that? You're no gen'elmun! As I wuz sayin', Constance— Sure, them engine pushers is hugs!

❖

San Francisco recently moved an 8000-ton, three-story school building across sand lots, over four streets and two car tracks, and set it down without hardly displacing a brick. It's far easier to move a brick school than it is to move the average school board—and you have a wild desire to displace a load of brick, and shy them.

❖

A young man getting $75 a month got tired of comparing this carfare with the millions he handled, and then he copped half a million and lit out for the bright lights. Served the trusting trust company right. Perhaps it will pay the next man living wages and help him to keep honest.

❖

To what parlous state has Springfield, Mo., arrived that it must have an armed guard to protect its sewers from vandalism? Run the vandals through the sewer a couple of times. This is a sure cure.

❖

Every funny man in every funny column of every funny publication (except, perhaps, the "Congressional Record") in these United States has made facetious remarks anent the cur who beat his wife 2080 times in 40 years. We're going to keep mum—principally because our remarks would not be allowed to go through by the postal authorities.

❖

"How far must an engineer be guided by his client's resources?" asks John M. Goodell in the "Engineering News." Why didn't you ask us, John? Right off the reel, we'd get a line on how big the client's resources were, and then we'd keep a-inchin' and a-inchin'.

❖

The linemen had completed the wiring in a Delphos, Ohio, home and had "proved out," when the boss lineman noticed that a blank socket had been plugged with a champagne cork.

"Whadcha plug the socket for?" he began. "The juice won't ——"

"Ja, dot's it!" exclaimed the Teutonic mistress of the home. "Ach, dere no light is, undt I put me a cork in to keep der juice from running oudt undt spoiling der carpet!"

❖

They say that earthquakes have been drilling holes in the bottom of the sea. Somebody page McGinty and let us have the facts.

❖

The Sanitary Sons of Harvard, an organization of sanitary engineers! Pleasedtomeetyer! There's a big call today for clean men, and these sons must be clean to come right out in the open with the label.

❖

An old and valued contributor, who is alert to his literary shortcomings, writes that he refuses to die the longest day he lives. As he's "the livest reader 'Power' has," he's just going to keep aplugging. He doesn't give a durn what we editors think. Come across, Mac, as often as you like!

❖

Uncle Sam, have you no bowels of compassion? The charwomen, scrub-ladies and other humble toilers in the Capitol got their June pay on Oct. 31. Oh, Sammy!

❖

There is no such thing as a criminal type, declares Doctor Goring, of His Majesty's prison at London. Ain't, hey? I the printer set it "infernal" instead of internal combustion and "pullets" instead of pulleys— This is criminal type enough for us.

Refrigerating Engineers Meet in New York

On Dec. 1 and 2, the American Society of Refrigerating Engineers held its ninth annual meeting in the Engineering Societies Building, New York City. Three sessions were held on Monday and one on Tuesday, with an old fashioned beefsteak dinner at Healy's as a final to the convention. There were a number of good papers which were heard by a large attendance, and enthusiastic discussion on various points indicated the interest that had been taken in the society's work during the regime of Retiring President Neff. He had asked for coöperation, and as stated in his address had in a measure received it. Individually many of the members were doing yeoman service. More organized effort, however, was wanted. There was need of good team work, and unless the society awakes to its opportunities it may have to follow instead of lead. Reference was made to the work of the International Association of Refrigeration and the influence of the Congress recently held in Chicago. There were many problems in the field ripe for attention, and it was the president's urgent desire, that the society should attain in their solution the standing that it should have.

NOT CHEFS BUT MEMBERS OF THE AMERICAN SOCIETY OF REFRIGERATING ENGINEERS IN THE JUNGLE ROOM AT HEALY'S

The balance of the morning session was devoted to routine business, an expression from the floor favorable to holding the next Western meeting in San Francisco in 1915, and the announcement of the following officers for the year to come: President, Henry Torrance, Jr.; vice-president, Theodore O. Vilter; treasurer, George A. Horne; directors, V. R. H. Greene, J. S. De Hart, Jr., A. P. Criswell, E. F. Miller and F. E. Matthews.

Monday afternoon the session opened with an interesting paper on "The Sterilization of Water by Ultra-violet Rays" by Max von Recklinghausen, of Strassburg, Germany. Although not relating directly to refrigeration except in the sterilization of water for ice making, the paper was well received and brought forth many pertinent questions from the audience. It developed that the cost of treatment amounts to about 30 watt-hours per ton (about 240 gal.) of water, and that the average life of the lamps used for the purpose approximated 3000 hr.

John C. Sparks followed with his paper on the "Chemistry of Raw Water Ice," dealing especially with the agitation and, therefore, the volume of air required for different waters. The author had made a series of tests on the proper amount of agitation with the purpose of correlating the three factors: Size of can, temperature of brine and quantity of mineral salts in solution. The tabulated data showed that there was a direct relationship between the mineral salts in the water and the volume of air required, and extra agitation should be provided when the speed of freezing is increased. For a 300-lb. can of water containing 4 grains of solid matter per gallon 6.5 cu.ft. of air per minute were required. In the discussion it was shown that to compress this much air would require an excessive amount of power per ton of ice—so much more than was used in practice, that it was suggested the decimal point had been misplaced, the usual amount being much nearer 0.65 cu.ft.

Papers on "The Refrigerator Car—Retrospective and Prospective," by Eugene F. McPike and J. H. Bracken, both of Chicago, and their discussion ended the session.

The evening session, although not brimming over with information new or particularly instructive to the refrigerating engineer, was perhaps the most entertaining of all. C. H. Stevens, of the Brooklyn Edison Co., read his paper on "Electricity for Ice Making and Refrigeration as Supplied by the Central Station." In the early paragraphs the author had stated specifically that the paper would dwell principally on the question of rates. The audience was looking for just this information, but was doomed to disappointment. Mr. Stevens told them why their generating cost was lower than that of the isolated plant, the purchase of immense quantities of coal, its cheaper handling due to better facilities, and the high efficiency of the large units being the principal reasons. The cost of distribution was practically negligible as to a refrigerating plant current was transmitted directly at high voltage from the nearest generating station. As to profits these were extremely low. The central station could give low rates as the maximum refrigerating load came at the right time of the year to better their annual load factor. Systems of charging were explained and some useful tables were incorporated giving the power required for refrigerating and ice-making purposes, but not a word on rates, the information the audience was looking for and that which they had been led to expect by the author himself.

In the discussion C. G. Armstrong, of New York City, favored motors for small refrigerating plants but in most cases had not found the rates satisfactory. In the central station the operating cost was less, but this did not take into account the expensive selling force, the heavy transmission loss, the difficulty of transmitting the power from the

motor to the compressor, and the probability of using exhaust steam for heating. There were cases where the power should be purchased but generally the isolated plant gave the best results. The whole question was not how the central station could do it, but for what they could sell current. As expressed by John E. Starr, it was a question of bargain and sale. Approximately 43.77 kw.-hr. were required per ton of refrigeration. Uptodate engineers of today are fairly well posted on the cost of an isolated plant, the extra labor required for firing, depreciation and fixed charges, etc. It is not a question of how, but what can the central station sell at?

Mr. Fairbanks of the Quincy Market Cold Storage & Warehouse Co., of Boston, said that this company had discussed the question of rates with the Edison Electric & Illuminating Co. The company has a peak load of 10,000 hp., mostly refrigeration and some power and lighting. For 24-hr. service the best rate they could obtain was 2c. per kw.-hr., and as they were already producing the same unit for ¾c. it was not deemed advisable to scrap their plant.

J. L. Plock referred to an ice plant in Brooklyn which was paying a 2½c. rate to the Edison Co. Adding fixed charges to this would sink the company on $2 ice. Charles H. Herter called attention to the 150-ton raw-water plant of the Bay Ridge Manufacturing Co., of Brooklyn, which was furnished power for the year at a minimum charge of $18,000, amounting to about 0.8c. per kw.-hr. This rate was explained by T. I. Jones, of the Brooklyn Edison, on the basis of the annual load factor. In January and December, that is at both ends of the year their output was maximum, and during the summer months there was a deep valley in the load curve. To fill this up with a load heavy in summer and light in winter was the aim of the company. The refrigerating plant had just this characteristic, so that the company could afford to dispense with the fixed charges and make a rate that would allow only a small profit on the operating cost. The company had a sliding scale of $80, $75 and $70 per kilowatt per year, and by dividing by the hours of service in each particular plant, it would be an easy matter to determine the rate per unit.

It was the consensus of opinion at the meeting that it was rather hard on the light and other power users to be forced to pay all of the fixed charges, and that the proposals made by Mr. Jones smacked of discrimination. Mr. Price, of the De La Vergne Machine Co. gave some data to the effect that an oil-engine plant could furnish power on 3½c. Mexican oil at 17c. per ton of ice, which with an allowance of $200 for lubrication would make the power charge at the Bay Ridge plant $7000 instead of the $18,000 charged by the Edison Co. The engine installation would cost $30,000 more, but with an annual saving of $11,000, the plant would pay for itself in three years and after that save $11,000 annually over Edison current.

An interesting talk by F. N. Speller on "The Manufacture of Pipe from Ore to the Finished Product," illustrated by moving pictures, was the feature of the evening session. The pictures were excellent and in following the metal from mine to pipe, gave a consecutive idea of the various processes that could never be obtained by a casual inspection of the mills.

In the fourth and last session on Tuesday morning, E. S. H. Baars' paper reviewed the feed systems of refrigerating coils and their respective advantages. Naturally the paper took up the three groups into which the various systems may be divided: The force feed or direct-expansion system, the gravity feed on flooded system and systems which are a combination of the two. This paper will be given further attention in an early issue.

J. C. Bertsch read a paper on "The Saturatic Cycle of Compression." In this cycle the vapor remains saturated throughout the entire operation. To prove that such a cycle is not only practical but the most efficient of all practical cycles, the author by means of simple entropy diagrams and tabulated data compared it with the purely theoretical Carnot cycle as well as with the wet, dry and strictly adiabatic systems. Severe criticism of the paper was made by Prof. L. S. Marks, of Harvard University. He objected to the term "Saturatic" and to the author's representation of the Carnot cycle. The efficiency of the Linde cycle as given was not correct and this put all the other cycles in error. The deductions for practical working were wholly gratuitous and the method of calculating the heat exchange in the walls of the compressor cylinder surrounded with ammonia was not in accordance with facts. The time of compression (about ⅛ sec.) was so short that there was no time to reduce the body of the gas to anywhere near the temperature of the cooling walls. An oral reply was not vouchsafed by the author, but a written discussion was promised in the near future.

"Defining the Heat Conductivity of Insulators," by Charles H. Herter, was the final paper, which was interesting and valuable as it compared the various methods of testing insulation now employed, the results obtained and incidentally showed that the formula most generally used for calculating the flow of heat through a wall or insulated surface overestimated the insulating value of nonconductors by 10 to 20 per cent. The author emphasized the difference between air and surface temperatures, showed the effect of air velocity and humidity, explained the construction of a temperature curve and in conclusion suggested a standard method of reporting conductivity tests in which all the data necessary would be included. A direct comparison would then be possible between different insulating mediums.

H. C. Dickinson of the Bureau of Standards stated that the Bureau had made a start in the testing of insulation. There were three factors to be considered; the heat conductivity of the insulation, heat transmission by convection and heat transmission by radiation. Tests as now conducted introduced these three indefinite factors and in attempting to obtain all of them at the same time error is sure to result. Two of the variables should be eliminated, convection and radiation, and it would then be easy to determine the conductivity of the material, which is really the factor that differentiates one type of insulation from another. The other factors could be determined afterwards by separate tests.

F. E. Matthews thought that the point of greatest importance was, what the insulation was going to do after it was installed. It was essential to first get the heat conductivity of the material itself, and this should be closely followed by the total conductivity of the installation, which would include surface resistance on which there was very little authentic data. A committee to coöperate with the Bureau of Standards was suggested and a motion to this effect passed, the appointment being left to the incoming president.

Mr. Dickinson was then called upon to explain the Bureau's method of testing. The apparatus consisted of three copper plates, about 8 in. square, in which were embedded sensitive thermo-couples to give the temperatures. Between the plates the insulation was placed and it was an easy matter to obtain the conductivity per unit of surface. The conductivity of air from thicknesses of 0.01 to 1 in. could also be obtained. In completing the discussion Mr. Herter explained his method of employing hot- and cold-water tanks with the insulation between.

Only a few minutes before adjournment one of the topical discussions on "Ammonia Purifiers or Regenerators," was started, but developed into a rather indefinite discussion on the temperature at which ammonia disintegrates.

The dinner in the evening in the Jungle Room at Healy's was an enjoyable event which helped to bond the ties of friendship and draw closer together the attending members of the society. John E. Starr was toastmaster and his selection was surely a happy choice. Speakers from the states of Washington, Utah, Illinois, Kentucky and on East to the Atlantic were listened to with interest, and of them all the eloquent address of Retiring President Neff will be remembered in years to come. His enthusiasm in the work of the society and sincere interest in the younger members were again in evidence and appreciated by the diners.

Lecture on Lentz Engine

About 75 engineers listened to an interesting lecture on the Lentz engine and superheat, by Mr. McHose, of the Erie City Iron Works, before No. 3 Association, N. A. S. E., at Newark, N. J., Monday evening, Dec. 1.

Mr. McHose pointed out that poppet valves had long been used in marine practice where slow speeds prevailed, and that later in Germany, this type of valve was improved and adapted to high speeds. At present the Lentz engine, using poppet valves, is adapted to speeds up to 350 r.p.m.

To show the advantage of this type of valve over a Corliss valve for the same power engine, an illustration (lantern slide) was thrown on the screen, showing the relative sizes. The Corliss valve had six times as much rubbing surface and considerable additional weight, requiring more lubricating oil and more power to operate. It was pointed out that the poppet type of valve was much better adapted to high superheat, so essential to good economy.

Some interesting views of European power plants using Lentz engines were shown. The engines in one of these plants operate at 192 lb. pressure 270 deg. F. superheat and 26-in. vacuum. Views of locomotives; both industrial and express, using poppet valves were shown.

An illustration of an old Sulzer engine (a poppet-valve engine of German make) which, the speaker said, was imported in 1885 for a brewery was shown. Mr. McHose claimed that

the engine had been in almost constant service since its installation, and the valves have never been reground.

In the discussion which followed the lecture, Mr. McHose stated that no trouble was experienced in finding an oil to give good lubrication under very high superheats. He mentioned that there were many plants operating Lentz engines under 200 lb. absolute steam pressure and 200 deg. superheat, a total heat of

$$381.9 + 200 = 581 \text{ deg. F.}$$

A not uncommon practice in Germany, the speaker said, was to operate engines at 200 lb. steam pressure and 250 deg. F superheat.

When the engineers for the Erie City Iron Works, licensed builders of the Lentz engine in the United States, visited Germany to investigate the Lentz engine, they found many industrial plants of about 100 hp. using highly superheated steam. Locomobiles using poppet valves were shown.

McIntosh & Seymour Corporation to Manufacture Diesel Engines

It is announced that a New York State charter has been granted to the McIntosh & Seymour Corporation, which will engage extensively in the manufacture of a complete line of stationary and marine Diesel engines. The company will be backed not only by large American interests, but also by Swedish capitalists who now control the Swedish Diesel Motor Co., which has a wide reputation as the builders of Diesel engines on the Hesselman system.

The new corporation will take over the plant and organization of the McIntosh & Seymour Co., of Auburn, N. Y., whose present steam-engine business will be continued.

The board of directors is composed of Marcus Wallenberg, president Stockholms Enskilda Bank, Stockholm, Sweden; Frank A. Vanderlip, president National City Bank, New York; Thatcher M. Brown, Brown Brothers & Co., New York; Edwin S. Church, Auburn, N. Y.; J. A. Seymour, Auburn, N. Y.; Franklin B. Kirkbride, New York City; Oscar Lamm, Stockholm, Sweden; Philip W. Henry, New York City. The general counsel is W. M. Coleman, New York City. Edwin S. Church, formerly superintendent of the Akron plant of the International Harvester Co., will be the executive head of the new corporation, and J. A. Seymour, president of the McIntosh & Seymour Co., will be the vice-president and in charge of engineering. The initial capitalization will be $2,200,000 and the stock one-half common and one-half 6 per cent. cumulative and participating preferred.

In 1898 the Swedish Motor Co. started building these engines. Many of the designs, as the fuel pump, the atomizer, details of pistons, etc., have been purchased and adopted by many other leading European builders of Diesel engines. Chief Engineer K. Jonas E. Hesselman has been knighted by the Swedish Crown in recognition of his distinguished achievements in this line.

The McIntosh & Seymour Co. in the past has been most successful in this country, and has a large export business.

It has for some time been commented upon, in view of the successful Diesel-engine business being done by many European concerns, that no attempt has been made in this country to build a full line of Diesel engines of a design which has proved to be a commercial success in actual use and where the actual cost of fuel oil is generally much lower than in Europe.

In addition to furnishing exclusive licenses for their valuable patents for the Western Hemisphere, the Swedish interests in the new American company insure their active aid and coöperation by furnishing a large part of the working capital, and furthermore, will take an active part in the actual building of the American engines. Mr. Wallenberg, the principal stockholder of the Swedish Motor Co., and Mr. Hesselman, the chief engineer, have been in this country investigating the situation, and the sizes and speeds desirable to conform to American standards and conditions.

National Conservation Congress

At its fifth annual session, held in Washington on Nov. 18, 19 and 20, the National Conservation Congress split into two factions over questions of grants of water power sites and control of water-power companies. The majority faction, led by Gifford Pinchot, father of the congress, adopted resolutions after three days of acrimonious debate, declaring that no grants of water-power sites should be made in perpetuity, while perhaps a hundred delegates who opposed this action and had urged that all powers of regulation be left in the hands of the states instead of the Federal government, left the convention and announced their purpose of calling a convention in the near future for the organization of a rival conservation association.

The states rights proposals were voted down, and the Pinchot resolution adopted by a vote of about three to one. The resolution which led to the breaking up of the convention in confusion, was as follows:

WHEREAS, concentrated monopolistic control of water power in private hands is swiftly increasing in the United States, and far more rapidly than public control thereof; and

WHEREAS, this concentration, if it is fostered, as in the past, by outright grants of public powers in perpetuity, will inevitably result in a highly monopolistic control of mechanical power, one of the bases of modern civilization, and a prime factor in the cost of living; therefore,

BE IT RESOLVED, that we recognize the firm and effective control of water power corporations as a pressing and immediate necessity urgently required in the public interest;

That we recognize that there is no restraint so complete, effective, and permanent as that which comes from firmly retained public ownership of the power site;

That it is, therefore, the solemn judgment of the Fifth National Conservation Congress that hereafter no water power now owned or controlled by the public should be sold, granted, or given away in perpetuity, or in any manner removed from the public ownership, which alone can give sound basis of assured and permanent control.

Opponents of the Pinchot ideas, which gave rise to the conservation movement during the Roosevelt administration, declared in the congress that up to the present time the whole movement had been one of "reservation" rather than conservation. Although the critics of the government's water power policy were in the minority in the congress, they were loud in their denunciation of the effects produced by the reservation of power sites from unrestricted development. The delegates who fought to reverse the present policies, and joined the secession ranks when they were beaten were almost wholly from western and southern states.

Three reports from the water-power committee, presented on the first day of the sessions of the congress, started the fight, which monopolized attention to the practical exclusion of consideration of forestry, which was on the program for the main topic of debate.

The minority report, upon which the Pinchot resolution was based, and which provoked the most criticism, was signed by Mr. Pinchot, Joseph N. Teal, of Oregon, and former Secretary of War Henry L. Stimson, of New York. Those who signed the majority report, which urged a more liberal policy in the granting of rights to water-power companies and apparently objected to the inclusion of certain statistics from the report of the commissioner of corporations, were George B. Swain, Lewis B. Stillwell, Marshall O. Leighton, Edwin S. Webster and B. M. Hall.

A general statement of the broad principles of conservation, upon which the committee was unanimous, was presented by Mr. Stimson, and was adopted by the convention without opposition. This summary proposed that no grants or leases of power sites should be made except under regulation, for the protection of the public interest at stake.

The minority report declared that the central fact and gravest danger in the waterpower situation is concentration of control. Ten groups of power interests, it asserted, control 65 per cent. of all the developed waterpower in the United States, and some of these groups are further related through interlocking directorates. While two years ago the ten largest groups of waterpower interests controlled but 3,270,000 hp. developed and undeveloped, it was declared, today the ten greatest groups control 6,270,000 hp., the amount of concentration toward monopoly having doubled in two years. Concentration in ownership of waterpower, it was said, has increased in five years about seven times faster then power development.

These facts, the report asserted, showed the fallacy of the charge frequently made that conservation has locked up water-power sites and prevented their acquisition for development. The waterpowers held by the ten greatest groups of power interests, developed and under construction, for the years 1911 and 1913, as compared with the undeveloped waterpowers held by the same interests, were shown to be as follows:

	1911	1913
Developed horsepower	1,821,000	2,711,000
Undeveloped horsepower	1,450,000	3,500,000

In refutation of the charge that the system of regulation under which the waterpower sites in the Forest Service are granted is stifling development, discouraging capital and holding back industry, the report showed that of the total waterpower development in the United States to date, nearly one-third has been developed or is licensed for development in the National forests, under government regulation.

"The fight for the conservation of the public waterpowers," the minority report asserted, "is first of all a fight against monopoly. But the second prime necessity in the public interest is to forbid and prevent the speculative holdings of powers unused, and to force the prompt and full de-

elopment of the vast aggregate of power resources now eld idle and unproductive under concentrated private con-rol. If we take the valuation of $45 per horsepower, the vaterpowers now held undeveloped in the control of the ten reat groups of interests, represent a total annual loss to he country of $160,000,000 worth of power.

The three essentials of a sound waterpower policy, de-lared the minority report, should be: (1) Prompt develop-ent; (2) Prevention of unregulated monopoly; (3) Good ervice and fair charges to the consumer. All interstate power usiness should be under Federal control and regulation, de-lared the report, as should also all development of water-owers on navigable streams and those in the National orests and the public domain. The minority report recom-ended that franchises for grants of power sites and power rivileges under government regulation, should be made for ot longer than fifty years, with the power in the hands of he government to revoke the franchise for cause at any ime, and to revoke it at the discretion of the government fter thirty years. Such franchises should be non-assignable nd non-transferrable except with the consent of the govern-ent, and the government should participate in the profits of he operating companies above a fixed percentage on the in-estment, to be stated in the franchise. It was also pro-osed that in cases of waterpowers on navigable streams, the roceeds derived by the government should go to the im-rovement of navigation.

The majority report, presented by Professor Swain, of Harvard, was a lengthy document which referred briefly to he dangers of monopoly shown by the control of 65 per ent. of all the developed power in the country by ten groups f waterpower interests, and placed great emphasis upon the ecessity for prompt development of water powers to en-ourage industry and conserve the coal supply. In order to ncourage investment of private capital in waterpower en-erprises, the Swain report proceeded, three essential features f a waterpower policy must be: (1) Definiteness in the con-ract entered into; (2) The prospect of a sufficiently attrac-ive return, commensurate with the risk involved; (3) The rotection of the courts in case of dispute.

In the case of navigable streams as pointed out by the najority report there are two conditions to be considered: Where the Government builds the dams to improve naviga-ion and where the dams are built by private capital for the levelopment of power. In the first case the waterpower is a yproduct of the navigation works and inasmuch as the Gov-rnment has gone to the expense of building the dam, the rantee of the power permit should pay a reasonable com-ensation. In the second case, however, the Government may e benefited through greater navigability of the stream with-ut expense to itself and the interests of conservation may e best served by making no charge, the improvement in avigation brought about by the construction of the dam and ocks being accepted in lieu of charge. The Secretary of War should see to it, however, that the operation of the lant will not obstruct navigation.

The Swain report favored the granting of indeterminate ranchises for power sites, subject to revocation only upon ayment of the fair value of the property. Where applica-ion was made by states or subdivisions of states for in-leterminate grants of power sites on navigable streams or n the public domain, the report proposed, the government hould not exact a return.

The final paragraphs of the Swain report were the por-ion of the document which raised the clear issue between it nd the minority.

"For the conservation of our waterpowers," these para-graphs asserted, "it is esential that capital should be at-racted to these enterprises, and while we must, of course, ully protect the interests of the public, both present and uture, we are not conservationists if we advocate the im-osition of terms which restrict rather than encourage de-elopment. We must also remember that under present con-ditions waterpower investments are not especially attractive, nd that steam power is a more desirable form of power, since it can be located where needed, and the supply regu-ated according to demand. Waterpower is more variable, nd furthermore it requires, in general, a very much larger nvestment per horsepower than steam, though its running xpenses are less. Because of the large first cost of water ower developments the risk of loss in case of failure of the nterprise is correspondingly large. Capital, therefore, does ot need waterpower enterprise, and it will not take them up o any considerable degree, unless fully protected.

"It has been estimated that we use annually over 480,000,-00 tons of coal, worth nearly a billion dollars, in addition o many million dollars worth of other fuels; and that some $200,000,000 worth of this fuel might annually be saved by he utilization of waterpowers. When we consider also that the development of waterpower not only conserves fuel, but directly serves to promote the navigability of rivers, we should be very careful how we discourage this triple con-servation in order to secure other results that we may con-sider desirable. If we do discourage it we may be anti-monopolists, or something else, but we are certainly not conservationists."

Pointing to the fact that Mr. Webster, who signed the majority report, is a member of one of the largest firms of water power promoters in the United States, Pinchot adher-ents declared that the majority report represented the special interests of waterpower promoters and exploiters, which it placed ahead of the public rights and interests in the subject. It was also freely charged that from some of the states, the delegations had been packed in the interests of private-power interests. Western and Southern delegates who op-posed the declaration for Federal control, and finally seceded from the congress, retorted that the majority of the congress was controlled by former cabinet officers under Republican administrations, and had been packed with government em-ployees by these former officials.

A resolution urged by Southern delegates, declaring that all waterpowers should be under exclusively state regulation, was voted down by about the same vote by which the Pinchot resolution was finally adopted.

One of the sensational features of the convention was the speech of Frank S. Washburn, president of the American Cya-namid Co., who charged Pinchot with being responsible for the veto of the Coosa River dam bill, and declared that this policy had driven from the United States a great industry. The Cyanamid company, he said, had been preparing to locate a plant on the Coosa river which would have cost millions of dollars, for the production of nitrogen from the air. The location of this plant would have built a city about it, given to the country a new industry, reduced cost of fertilizer and increased crop yields. When the Coosa river bill was vetoed, he said, his company located in Canada. Mr. Washburn, Senator Bankhead of Alabama, and other states-rights ad-vocates, insisted that the Federal government should keep its hands off, and permit any regulation of power companies and rates to be exercised by the states, which would be more liberal in their policy, and would be more active in en-couraging power development.

President Wilson and Secretary of State Bryan had been scheduled to speak at the congress, but did not put in ap-pearance. It was unofficially said that they stayed away in order to keep out of the dispute between the advocates of state and Federal regulation. A political tinge was also given the convention by the fact that practically all the ad-vocates of Federal regulation and ownership of power sites were officials formerly connected with Republican adminis-trations, while Democratoc members of the Congress from Southern states led the minority fight for state regulation, and were leaders in the bolt from the congress.

An expected fight to have the congress take action in opposition to the proposed congressional grant of reservoir and power rights in the Hetch-Hetchy valley, to the city of San Francisco, did not materialize.

SOCIETY NOTES

The trustees of the American Museum of Safety will hold a safety and sanitation conference at Rumford Hall, in the Chemists' Building, 50 East Forty-first St., New York City, on the mornings and afternoons of Dec. 10, 11 and 12, in connection with the International Exposition of Safety and Sanitation. The sessions promise to be most valuable to those interested in welfare work of any sort. Many well known men and women will speak or lead discussion. The conference will afford unusual opportunities for learning re-cent developments in the present nation-wide movement for accident and disease prevention.

PERSONALS

A. G. Machesney, for 15 years traveling engineer and loco-motive inspector with the Baldwin Locomotive Works, has become associated with the railway division of the Detroit Lubricator Co.

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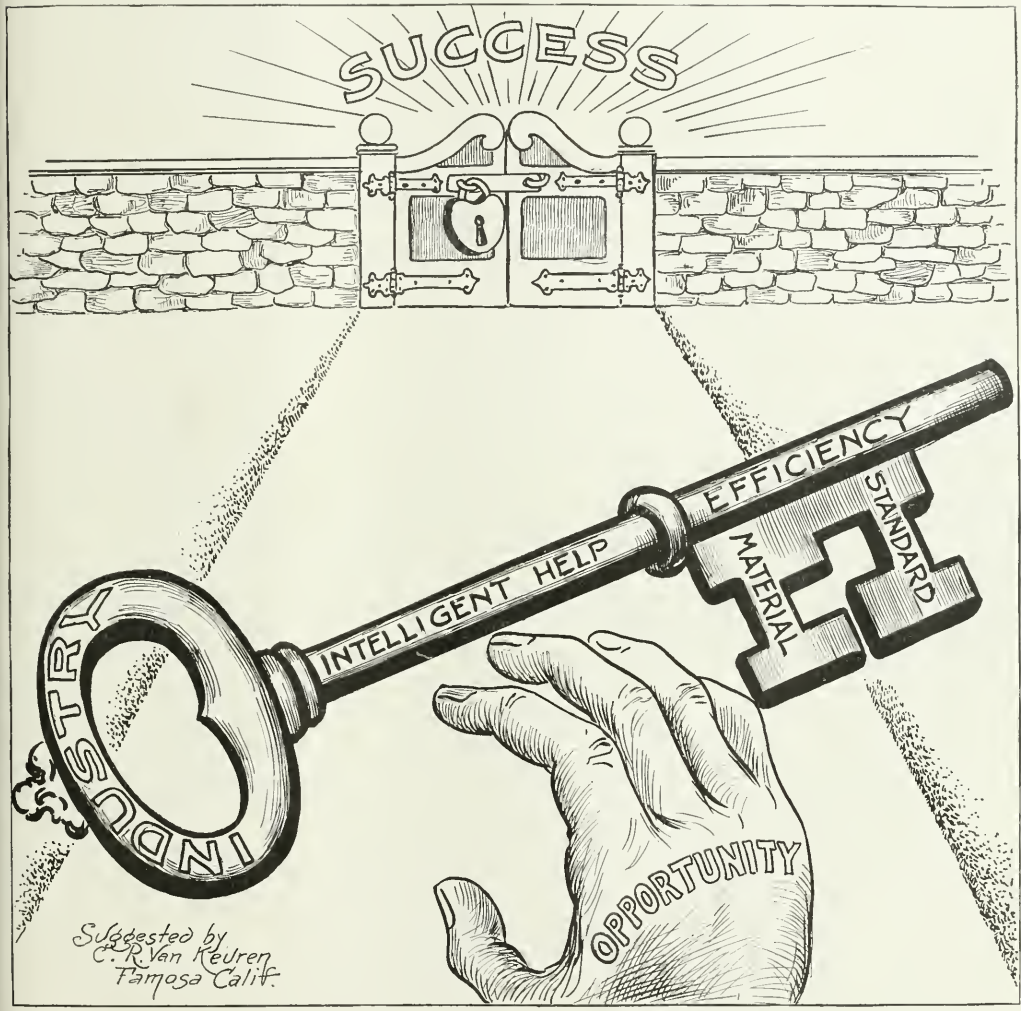


HOW TO GET THERE

ompressed-Air Pumping Plant, Meridian, Idaho

By LeRoy W. Allison

NOPSIS—Water from an 8-in. driven well is ob-ed by an air-lift system. Air is supplied by a motor-en air compressor, belt connected. Water is stored 60,000-gal. steel tank.

ne town of Meridian, Idaho, has erected a pumping on, with domestic water-supply system and fire-pro-on facilities, that offers many interesting features. cost of installation and daily operation commen-

Air-Lift Pumping Plant, Meridian, Idaho

e with results obtained, the plant and system during iod of more than two years' continuous operation has n exceptional efficiency.

Water Supply

site for the plant, including well, pumping station ower tank, was selected at the highest part of the An 8-in. well was driven to a depth of 242 ft. and n. tubing driven on down to the 252-ft. level. At oint the flow was encountered in a deep stratum of gravel underlying a stratum of tough, solid clay. ing to a point about 60 ft. below the surface, the had a depth of about 192 ft., and such level has almost continuously maintained. The water is ex-ly soft, nonmineralized and free from ammonia nts. As taken directly from the well, it has a con-temperature of approximately 52 deg. F.

Under the various conditions to be considered, among them being the size of well tubing, an air-lift installation was decided upon as being the most suitable and effective. An air compressor, driven by a gasoline engine was temporarily operated for testing and cleaning the well. The results obtained were highly satisfactory, indicating a practical inexhaustible supply, and conclusively proving the entire feasibility of lifting the water by a compressed-air system.

Pumping Plant

An exterior view of the pumping station, including the steel water-tower tank, is shown herewith. The well has a 6-in. outlet into a concrete receiving basin. This basin is 10 and 12 by 7 ft., 8 in. deep, and has a capacity of about 8000 gal. A 6-in. outlet for discharging to waste in an outside ditch is also provided; both outlets are fitted with controlling gates.

A concrete suction chamber, 12 ft. 10 in. by 36 ft. 7 in., and 8 in. deep, adjoins and connects with the receiving basin. At the terminus of this chamber, a 4x5-in., two-stage centrifugal pump is installed. Operated at 1120 r.p.m., this pump has a capacity of about 625 gal. per min., with the tank full. It lifts the water from the receiving chamber through a 5-in. discharge line and discharges it into the tank and distribution system. This pump is fitted to operate automatically by a float and weight which, when the water reaches a fixed level in the receiving basin, acts, by a system of levers, on a friction-clutch coupling on the pump shaft.

A 50-hp., three-phase, 60-cycle, 220-volt, alternating-current motor, with starting compensator, is directly connected to the centrifugal pump by this friction-clutch coupling. The motor is belt-connected at 18-ft. centers to a 10x12-in. air compressor, located at the receiving basin. The compressor is equipped with a 3½-in. automatic unloading valve and a 36-in. by 6-ft. vertical air receiver, and is operated at 165 r.p.m. Through a 1½-in. air pipe, suspended in the 6-in. well tubing, the air is sent down 170 ft. in the well. This air pipe is fitted with a reverse elbow at the bottom so that when released the air acts directly in lifting the volume of water.

Water-Works System

The water-works distribution system comprises about 20,000 ft. of 4-in., 6-in. and 8-in., extra-heavy, wood-stave, wire-bound water pipe. This pipe was carefully laid under expert supervision. The trenches were puddled from irrigation ditches, and the tenon ends of the pipes were painted with boiler asphaltum tar before being driven into the couplings. The pipe was kept from sunlight until placed, and is estimated to have a life of at least 40 years. Controlling gate valves divide the system into eight sections.

The steel water-tower tank is 110 ft. high from the top of the foundations to the water surface when full, and has a capacity of 60,000 gal.

Summary of Tests

Shortly after the installation of the plant, tests were made to accurately determine the capacity of the various

components of the station, and the 24-hr. domestic consumption in the town. The results of these tests showed that the maximum capacity of the well was about 225 gal. per min., with air at 38 lb. pressure. At present, after more than two years' continuous pumping, this flow has largely increased. The well capacity with about 40 lb. air pressure is now about 400 gal. per min., which more nearly equalizes the air-compressor and centrifugal-pump capacities.

The capacity of the centrifugal pump, with the tank full, was found to be about 625 gal. per min., as rated. The static head on the pump is about 112 ft., and the suction lift is not over 8 ft.

The time required to fill the receiving basin up to the point where the pump starts to operate automatically was found to be about 34 min.

When the centrifugal pump starts, there are about 7500 gal. in this chamber. To empty the basin when full, with the air compressor discharging from the well at the same time, requires about 18 min. By throttling the gate valve on the force main, the capacity of the pump can be reduced, so that when vitally needed, as in the case of a serious fire, a supply of about 220 gal. per min. can be obtained indefinitely.

The demands upon the plant and system have now considerably increased, but at the time of making these tests were found to be about 64,000 gal. every 24 hr. Based upon meter requirements, and a study of consumers, the estimated actual daily consumption per capita was between 90 to 100 gal., or a domestic daily consumption of about 40,000 to 45,000 gal.

The water unaccounted for lies between 4000 and 9000 gal. per 24 hr. Considering, however, that the line loss, or water unaccounted for any other way, in a well constructed and carefully maintained cast-iron pipe system, with lead joints, will average between 2500 and 3000 gal. per mile of cast-iron pipe per 24 hr., it is seen that this wood-pipe distribution installation is more efficient than the average cast-iron pipe system.

The entire cost of the pumping plant and water-works system was about $24,000 complete. It was designed and erected under the supervision of Edmund M. Blake, to whom the writer is indebted for considerable data regarding this plant.

Further Studies in Corrosion

In addition to the recent studies in corrosion (POWER, Oct. 11, 1913, p. 531; and Oct. 28, 1913, Nov. 18) it is worth while to abstract the conclusions in other recent publications treating this subject. In Technical Paper No. 15 of the Bureau of Mines ("An Electrolytic Method of Preventing Corrosion of Iron and Steel"), J. K. Clement and L. V. Walker have told of studies in the corrosion of iron tubes in diluted acids. They refer at some length to G. Harker's and J. McNamara's results (*Journal Soc. Chem. Ind.*, p. 1286, 1911) in which an iron anode connected to an outside source of power is used to prevent corrosion. Harker concluded that the counter e.m.f. did not prevent the solution of iron from the boiler tube, but that other iron is deposited as fast as it dissolves. From this Clement and Walker differ, but the disagreement is of no consequence to the operating engineer.

However, one practical conclusion of Clement and Walker's is important, they state that a carbon anode (insoluble anode) works equally well with an iron one, if the correct counter e.m.f. be applied. That is, using an external source of power, neither zinc nor iron anodes are necessary, carbon will do the trick. Corrosion and, consequently, the protective current required, are greatly increased by oxygen present in the water, by increase in acidity and by stirring.

The authors give a table by which it is claimed the current necessary for protection can be deduced, but the way of applying it to a boiler or other steam apparatus in actual operation seems to be a mystery. However, it appears that under their experimental conditions three milliamperes per square inch were sufficient to prevent corrosion even with fast stirring. This is equal to 1.75 watt per sq.ft. of protected surface, or 6.6 kw.-hr. per sq.ft. of surface per year. Nothing is said of how far from the electrode such protection extends or of calcium-carbonate protective coatings, as in the Institute of Metals report.

The Microchemistry of Corrosion

A paper by Cecil H. Desch and Samuel White before the Institute of Metals (of Great Britain) deals with microstructure of corrosion. We abstract the conclusions only. They emphasize especially in any experiments dealing with corrosion of brass, the necessity of distinguishing between metal dissolved and that left as a dezincified layer, which may later become detached. In absence of mechanical disturbance, this may be a protection against further loss: usually, however, it is scaled off, exposing fresh surfaces to attack.

There is no evidence that tin alloys have less initial tendency to corrode than pure copper-zinc alloys. The protective action of tin seems mainly mechanical, due to the formation of a peculiarly tough and adherent coating of basic salt, which acts like a protective paint. The presence of iron in the brass greatly accelerates corrosion.

In some experiments of J. Newton Friend, Walter West and J. Lloyd Bentley (*Transactions Iron and Steel Institute*, May, 1913), there seem likewise to be some points worth cognizance by the engineer who is experimenting on corrosion. Certain nickel and chromium steels are more resistant than any carbon steels to corrosion by tap and salt water, high-nickel and high-chromium alloys being most resistant. Nickel steels show less superiority in long tests than in short, they show a wonderful resistance for a time, then break down rapidly, pointing to the conclusion that short trials are not enough. To exercise appreciable influence, the nickel percentage should be over three. A little chromium seems to accelerate the solubility—there seems some reason to believe that with about 5 per cent. the maximum insolubility is reached, and that above that excess chromium again increases the solubility. Nickel-chromium steels are more corrodible than when either metal is taken alone.

Last, and most important to the experimenter, they state:

"It is evident that results in acid-corroding media give relatively no clue to the corrodibility of the metal under ordinary conditions of exposure. This, again, emphasizes the fact that acceleration tests as usually carried out with acids yield misleading results."

This is only too true.

Condenser-Tube Corrosion

In a paper before the Institution of Engineers and Shipbuilders in Scotland (Trans., 56th Session, p. 37), J. H. G. Morrison gives a review of the electrolytic theory of corrosion, then passes on to the practical side, basing his results somewhat on acid-acceleration tests. He believes that lead and iron in the alloys should be kept as low as possible; that zinc plates in the condenser prevent dezincification; and that lining the tubes is a good corrosion preventive, if well done; but if not, is worse than useless.

He also believes that pieces of carbon or cinder, lodging on the tube, may start pitting, apparently in disagreement with Bengough. He suggests placing ash ejectors on the opposite side of vessels from the main injection, and to avoid pumping bilge water through the condenser. Tubes should all be annealed. The exhausts from auxiliaries should be placed so steam does not impinge directly on the tubes. No vegetable or animal oil should be used on any part of the engine whence it can work into the condenser. The speed of the water through it should be not less than 100 ft. per min., to prevent salts from depositing on the tubes.

The remarks of William H. Walker before the Society of Chemical Industry on Apr. 25, 1913 (*Journal Soc. Chem. Ind.*, June 16, 1913, p. 584), are of more than common interest, for Professor Walker has long been the leading exponent of the electrolytic-corrosion theory, and in this speech seemed to depart from it. He says, in part:

> In the first place we have found that the factors controlling the rapidity or extent of corrosion are by no means so simple as they were at first thought to be. Many conditions which were considered of little or no importance, have been found to exert a profound influence upon the reactions involved. For example, samples of iron and steel which exhibit marked differences in corrosion exposed in the normal condition in which they came from the mill, fail to show any difference upon exposure, when they are first planed to a uniform surface. Apparently the mechanical strain to which the samples are subjected in the planer, masks or neutralizes the difference in corrosion inherent in the normal material. It is not surprising, therefore, that many conflicting results have been obtained and published from the investigators now interested in this work. Only those tests which have been carried on under identical conditions of surface finish, temperature, access of oxygen and moisture, general atmospheric conditions, etc., should be given any weight, and even when the greatest care is taken, generalizations must be drawn with caution.
>
> One of the conclusions reached by a consideration of the electrolytic theory of corrosion which has proved misleading, is that homogeneity in the material insures protection, while heterogeneity leads to rapid attack. While this is a corollary which may be logically drawn from the electrolytic theory and is doubtless in itself true, there are evidently other factors which superimpose themselves upon those due to differences in structure, producing a final effect contrary to that predicted. The iron of the old chain bridge at Newburyport, Mass., has withstood corrosion in a truly remarkable manner for the last 98 years; and yet it is conspicuous for its heterogeneous structure. Large areas of perfectly pure iron, free from both carbon and slag, are mixed up with areas showing at least two kinds of slag, and very high carbon; yet all withstand atmospheric corrosion. On the other hand, Burgess has shown that iron free from all contaminating elements which could segregate or produce a lack of uniformity, does not withstand rusting so well as the same iron to which has been added a little manganese or copper or nickel. This behavior is observed also in the case of the so called pure irons made in an openhearth furnace, and which are relatively free from carbon, manganese, sulphur, and other constituents prone to segregation, which have come to the writer's notice. While theoretically a pure iron should withstand rust, there are apparently some factors present which more than offset any advantage inherent in purity. Obviously, conditions affecting the surface of the material so soon as rusting has started, are important causes which have largely been overlooked and which demand more thorough investigation. . . .
>
> Several hypotheses have suggested themselves as explaining the marked effect of copper in causing steel to resist atmospheric corrosion, but as yet none is sufficiently tangible to afford a working theory.
>
> Rapid progress has been made in acquiring that knowledge of the relation of pigments and finished paints to corrosion, which is necessary to a better protection of iron and steel. Predictions founded on theory that a basic paint, or one containing a chromate pigment would inhibit rusting while one made up from lamp black or graphite would accelerate rusting, have, in the main, been found correct. The effect of the pigment upon the character of the oil film making up the paint, however, has shown itself also to be very important. Many basic pigments, such as basic lead carbonate or zinc oxide, which in themselves inhibit, do not withstand the weather; lamp black and graphite, on the other hand, make a very impervious and highly resistant paint film. The logical conclusion in protecting iron is, therefore, to use a basic priming coat, a second coat of a mixture of a basic pigment and a little lamp black, and when well dried out to apply a lamp black or graphite finishing coat. Experience has shown also the importance of brushing the paint well on to the iron; a good paint may fail on account of poor application.
>
> Careful tests with galvanized work show that an even coating of zinc is the all-important factor. The common practice of clean wiping galvanized ware is fatal to durability, since the protecting layer is not metallic zinc, but a thin deposit of a zinc-iron alloy. While, therefore, much has been accomplished in the way of making a more resistant base, there is still a necessity for a uniform substantial coating of spelter over the surface.

❋

Automatic and Hand-Controlled Unloading and Reducing Valves

The purpose of this valve is, when placed in a steam line between a high- and low-pressure boiler, to automatically open and discharge the high-pressure into the low-pressure line to whatever pressure the valve is adjusted.

The valve shown in the accompanying illustration is in a closed position, due to the compression on the springs *BB*, which are adjusted by the nuts *AA*, thereby overcoming the high pressure on top of the diaphragm. When this pressure increases above the point at which the springs are adjusted, the valve will open. The position of the spindle, as shown, is for automatic service and is locked by the lever *F*. For closing the valve by hand, the lever *F* is thrown out of the locked position, which will allow the valve spindle *G* to rise.

The steam above and below the piston *D* and also above the diaphragm, prevents chattering or hammering and cushions the valve in opening and closing.

Should it be desired to renew the rubber diaphragm of the valve, which is made by the Golden-Anderson Valve Specialty Co., 1217 Fulton Bldg., Pittsburgh, Penn., the sleeve *C* is screwed down until it locks itself; this allows the piston *D* to come in contact with the seat *E*, closing off the steam pressure above the diaphragm by turning down on the handwheel.

In Fig. 2 is shown an automatic steam-pressure reducing valve in a closed position. The diaphragm *D* is of copper. When the pressure on the low side has reached the pressure at which the valve or springs are set, the pres-

sure, still increasing, exerts a pressure on top of the valve *H*, whose area is greater than *G*, and will force the valve closed. The valve in closing compresses the large springs, thus avoiding sudden closing, chattering or hammering. The port above the diaphragm is for the purpose of preventing any leakage of steam that may escape around valve and spindle, thus coming in contact with the diaphragm. The large piston *M* cushions the valve in opening and closing. These valves are desirable where accurate and constant regulation is required.

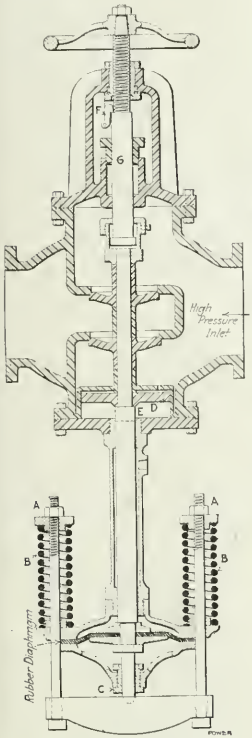


FIG. 1. HAND-CONTROLLED UNLOADING VALVE

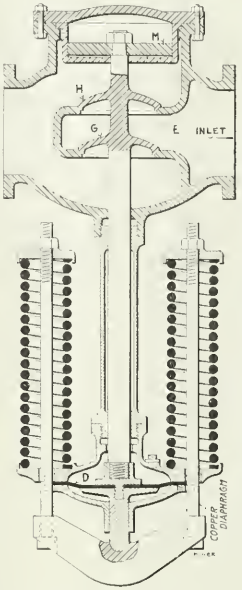


FIG. 2. REDUCING VALVE IN CLOSED POSITION

Crane-Erwood Double-Acting Non-return Cutout Valve

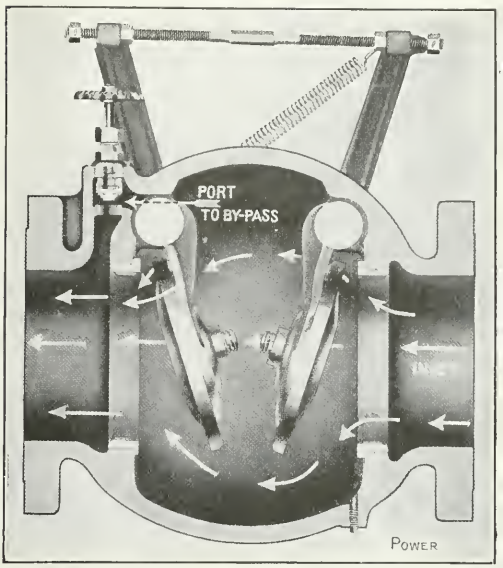
These valves are designed to close automatically in case the operator opens a large valve too quickly. It also acts as a protection to a boiler in the event of a tube bursting, as its nonreturn feature prevents the back flow of steam from the main.

The valve will also open automatically when the boiler to which it is connected reaches the full pressure in the main, but will remain closed at a higher pressure in the main; consequently a sluggish boiler may be readily detected.

In the accompanying illustration, a sectional view of the valve is shown. The levers on the outside of the valve are in line with the disks, and give an indication of their position at all times.

The separate link, connecting the outside levers, may be adjusted to suit the load to be carried. Shortening the link decreases the volume of steam passing through the valve; lengthening the link increases the volume and does not interfere with the automatic operation of the valve. The valve may be adjusted to close at any desired velocity, from the outside of the valve.

This valve, which is manufactured by the Crane Co., 836 Michigan Ave., Chicago, Ill., is made with a ferrosteel body and hard-metal seats and disks, and is adapted for operation on steam pressure up to 250 lb. at a maximum temperature of 500 deg. F. The valve may be arranged for electrical remote control and may be used for the protection of long lines of branch piping.



VALVE IN NORMAL POSITION WITH FULL VOLUME OF STEAM PASSING

Municipal Plants Good Assets—The light plant and water works are working successfully under ownership of Cambridge City, Ind., and are the biggest assets it has in keeping down tax rate. Recently a large addition was built to the light plant. It has three machines with an aggregate capacity of 350 hp. It will not be necessary to use the machinery to capacity for several years unless additional factory power is sold. The plant has a good day service as well as night and runs for 24 hours. Half a dozen factories use the power during the day and the streets are electrically lighted all night. Most of the houses are lighted by electricity. The water works, which has been town property but a short time, was improved a short time ago and now bears the distinction of using one of the two of its kind of filtering system north of the Ohio river. The water was formerly pumped from the Hagerstown canal but this was generally accepted as being unsatisfactory. The town board then ordered wells dug. At the depth of 30 ft. hard pan was struck. Boring through 5 ft. of hard pan, a vein of excellent water, flowing through gravel at the depth of 35 ft., was found. This is 5 ft. deep and rests on hard pan. The bottom of the supply well is 40 ft. deep. The filtering system is so arranged that the unfiltered water flows above in the well. Following the filtering process, the water is pumped up from the lower strata through the lower part of the filter.

Stationary-Boiler Pop Safety Valves

By Warren O. Rogers

OPSIS—A description of the method of adjusting owing-off point of the principal makes of pop safety , also the manner in which the amount of blow is adjusted.

e simplest form of safety valve is what is known as ead-weight type, in which the valve disk is held st its seat and the boiler pressure by a weight. Al- h this type of valve is simple it is cumbersome and daptable for high pressures. It is seldom seen in ountry except on heating boilers, although it was only used extensively in European countries before pressures prevailed.

th pressures ranging around 100 lb. the lever safety is common in many states. Although thousands of valves have been used in this country, they are not more than would be caused by the ordinary disk alone. This gives a larger opening at the seat through which a greater quantity of steam will flow in a given time in releasing a boiler of excess pressure. The other kind of valve has the additional area located at the center of the disk, and within the outer seat and excluded from the action of the steam by means of an inner seat, upon which when the valve opens the steam acts directly.

In either valve when the disk lifts from its seat, the escaping steam acts upon one or the other of these additional areas, causing the spring to be compressed in proportion to the power exerted upon the initial and additional areas respectively. This forces the disk to rise higher and affords an outlet for the discharge of steam greater than would otherwise have been provided had it not been for such additional area.

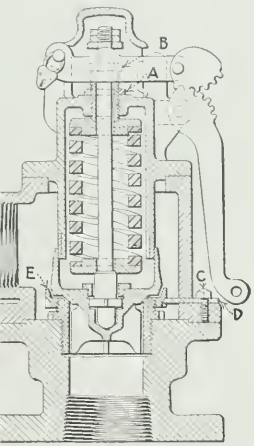


Fig. 1

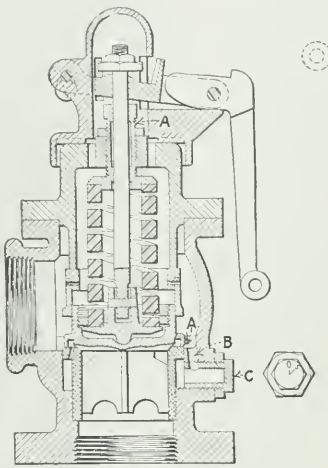


Fig. 2

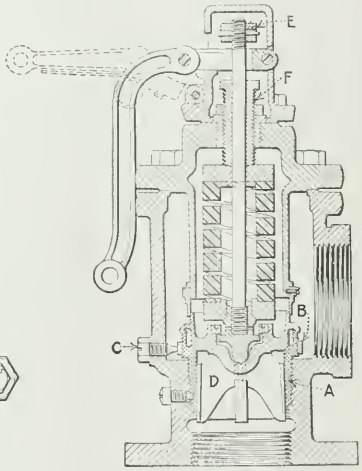


Fig. 3

dered a safe valve, because of the tendency to stick d of operating to relieve the boiler of excessive ure. According to the Massachusetts Boiler Rules, fety valves placed on boilers must be of the direct -loaded type. In fact, nothing but spring pop valves are now found in the better class of steam .

a pop safety valve the steam pressure acts upon the side of the valve disk, and is resisted by the ten- of a spring. When the steam pressure exceeds the nce of the spring the valve lifts from its seat and eam escapes to the atmosphere.

safety valves have been used in this country about ars, and have been in general use about 30 years. are two kinds of pop safety valves: one having an on to the valve disk, so designed that when the is closed the addition is cut off from the action steam, but when the valve opens the escaping steam the boiler acts upon it, which, with the initial force s the disk to rise higher and compressing the spring

As the safety valve is the most important fitting on a boiler it must necessarily be so constructed as to be sensitive to any excess pressure beyond the point at which it is set, and to give instant and positive relief to the boiler to which it is attached. In construction it must be durable, so as to maintain positive action under the most exacting conditions.

There are numerous makers of pop safety valves on the market, several of which are described and illustrated herewith.

Lonergan Valve

In Fig. 1 is shown a Lonergan pop safety valve. It is designed to give a large relief, that is, when in the act of popping the disk has a good lift off its seat, but not enough to relieve the boiler too suddenly, or to draw water out of the boiler. If the lift of the valve disk is too little the valve seat is likely to be damaged by the wire-drawing action of the steam in passing through the valve.

The valve is made to operate with a 0.10-in. lift, although it can be made to suit any requirement up to 1875-in. lift at the popping pressure. The spring, which is the principal factor in safety-valve construction, is made of steel and so designed that when compressed at the popping point the fiber stresses are not more than one-half of the fiber stress of the elastic limit of the steel of the spring.

Referring to the illustration it will be seen that the spring is protected from the steam by the relieved star valve on the outside of the spring chamber, thus doing away with back pressure on the top of the star. The spring chamber beside protecting the spring from the discharging steam also prevents back pressure on the top of the valve disk when the outlet is piped.

The spring rests on a spring step, which makes a ball joint with the spindle, to equalize any unevenness in the spring. The spindle has a bearing at least one-half the size of the valve diameter below the seat which reduces the friction to a minimum when the valve is in operation.

To prevent tampering with the adjustment of the valve after being once set, it is provided with a lock-up attachment, as shown. Another feature is the double-eccentric lifting gear with which the valve disk can be lifted one-eighth of its diameter off its seat, with no steam pressure under the valve seat.

This safety valve is adjusted for blowing off pressure by removing the cap and loosening the locknut *A*, and turn the compensating screw *B* to the left, or up, to decrease the popping point, and to the right, or down, to increase the popping point. One-quarter turn of the compression screw will change the popping point from 5 to 10 lb. After making any changes the locknut is tightened before putting the valve in service again. The blow down of this valve should be between 3 and 4 lb. before the valve closes after popping.

If it is desirable to change the number of pounds blow down, the cap bolt *C* is unscrewed and the ring pin *D* removed. A pointed instrument is then used to turn the adjustable ring *E* to the left, or up, to increase the number of pounds blow down, or to the right, or down, to decrease the number of pounds blow down. The ring should not be moved more than two or three notches at a time. If the valve shows a tendency to chatter, the adjustable ring should be screwed to the left, or up.

Ashton Valve

What is known as No. 20 iron-body Ashton valve is illustrated in Fig. 2. This valve is made to work with close regulation pop of approximately 3 lb. As indicated, the spring is inclosed in a casing and is thus protected from the volume of steam escaping from the boiler when the valve is operating.

The pop chamber is of special design in that it is surrounded by a knife-edge lip *A* and is inclosed within the walls of the lip and top of the bushing and valve seat. The knife-edge lip wears down in proportion to the wear of the seat of the valve, keeping the outlet of the chamber of the same relative proportion to the inlet, giving an unvarying pop and insuring long service without readjustment or repairs. A supplemental pop chamber is connected with the primary pop chamber by a series of relief holes *B*, through the bushing *C*.

Close regulation of the pop is made by adjusting the size of the opening into the discharge chamber. When it becomes desirable to adjust the pressure it is only necessary to remove the lock, pin and lever and after removing the cap, slack the check nut on the adjusting screw. Turning the screw downward increases the pressure, turning upward adjusts the spring for less pressure. Should a change in pressure of more than 15 lb. be desired, a new spring should be used.

Should it be desirable to change the amount of reduction in pressure when the valve operates, it is only necessary to regulate the screw-plug regulator *C* on the outside of the valve. If more pop is wanted, slack the check nut and turn the regulator slightly to the left, so that the letter *S* stands nearly perpendicular. For less pop the regulator is turned to the right until the letter *O* is nearly perpendicular. One-sixth of a turn of the regulator gives the full range of adjustment.

In order to give the spring a true bearing on the valve disk, it is fitted with pivoted top and bottom disks. The valve is made with a trip lever which can be changed to operate in any desired direction regardless of the position of the valve, and has the power to lift the valve disk from its seat at any pressure by hand.

Lunkenheimer Safety Valve

All approved patterns of safety valves are designed along similar lines, and of similar materials, the main idea being to make a valve that will operate promptly under the most exacting conditions. Such a valve is found in the Lunkenheimer safety valve, Fig. 3. In this valve the seat is beveled at an angle of 45 deg. to the vertical axis. It is provided with a lock-key attachment to guard against the adjustment being tampered with.

In this valve the bronze seat *A* is screwed into the valve body. The seat ring is provided with a regulating ring *B*, which is screwed up or down to regulate the pop. It is held in any desired position by the screw *C*. The valve *D* is guided by the wings on the bottom as it operates inside the seat ring *B*.

Provision has been made for regrinding the valve disk and seat by turning the stem *E*. The steel spring is held in place by top and bottom ball-seated plates, which keep the spring in alignment. The spring is protected from the action of the steam by the casing in which it is confined. The tension of the spring is regulated by the regulating screw *F*, which operates in a bronze bushing. A locknut holds the regulating screw in any desired position.

Should a higher pressure be desired the regulating screw is turned down; for a lower pressure it is turned up. The amount of escaping steam is regulated by the ring *B*. After removing the plug *C* a rod can be inserted to engage the notches around the regulating ring. Should the valve not reduce the pressure enough the ring *B* is turned up, covering the holes in the seat ring and causes the valve disk to lift higher and remain longer off its seat. If the valve reduces the pressure too much the ring *B* is turned down. When the desired adjustment has been obtained the ring is secured in place by the screw *C*.

Crane Valve

The construction of this valve embodies a self-adjusting feature which automatically regulates the pop of the valve and, thereby, permits moderate changes in the setting pressure and maintaining but little steam waste between the opening and closing points. It is necessary

in this type of valve to have a chamber into which the steam expands when the main valve opens, thereby creating an additional lifting force, in proportion to the increased area, sufficient to compensate for the increased tension exerted by the main spring, due to the further compression caused by the opening of the main valve. Therefore, the main valve is held open until the boiler pressure is relieved.

The pop chamber is relieved of pressure to allow the main valve to close promptly by the action of a self-adjusting auxiliary valve *A* and the spring *B*, which operate independently of the main valve and spring. The steam in the pop chamber passes through ports into an annular space provided in the auxiliary valve and lifts the valve disk against the tension of the auxiliary spring, allowing the steam in the pop chamber to gradually escape. This action supplies a balancing medium to ease the seating of the main valve disk without chattering or hammering. If it is desirable to change the point of blowing off within reasonable limits the screw-pressure

In Figs. 5 and 6 are shown the design of valve used for saturated and superheated steam in which the spring is comparatively large. It is supported by washers arranged for ball bearing on a spindle on the lower end and on a compression screw on the other end, whereby any distortion of the spring in compression does not cramp the spindle or cut the disk. The spring is protected from the heat of the escaping steam by the casing, as shown.

The popping pressure is adjusted by removing the cap and lever, loosening the check nut on the compression screw and turning the screw downward with a wrench to increase the popping pressure, or turning the screw out to decrease the popping pressure. When it is desired to adjust the blow down, the locking pin *A* in the side of the valve body is removed and the notched ring, which is threaded on the seat bushing, is turned upward to increase the blow down, or in the opposite direction to decrease the same. The usual adjustment of 5 lb. can be increased to 15 lb. if desired, or it can be decreased to less than 2 lb. The action of the valve, however, with a

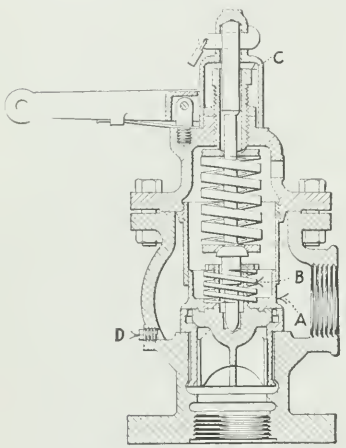


Fig. 4

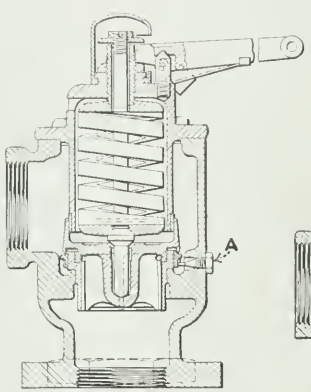


Fig. 5

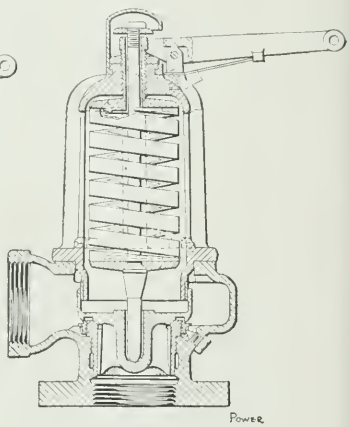


Fig. 6

plug *C*, at the top of the valve, is turned in or out for a higher or lower pressure. The valve is self-adjusting within reasonable limits and there is no necessity of readjusting the auxiliary valve to regulate the pop should it be desired to make a moderate change in the set pressure. The valve is provided with a cam lever which will lift the valve disk from its seat one-eighth the diameter of the valve opening; the lever can also be thrown over far enough to lock the valve open should occasion require.

Consolidated Safety Valve

Aside from mechanical reliability the most vital factor in a safety valve is its capacity, which is dependent upon the area of discharge through the valve or relieving capacity. The makers of this valve, after two years' experimenting, redesigned their line of safety valves to conform to the formula they found to be correct for determining the proper valve rating according to their actual relieving capacities. Therefore, with each type of valve a spring of suitable proportions was calculated and the valve case was then built around the spring.

blow down of 4 to 5 lb. is cleaner and more positive than with a lesser blow down. In the superheated steam valve the spring is placed above the discharge opening and is cooled by contact with the external air.

Crosby Pop Safety Valve

The iron-body Crosby pop safety valve is made in two styles, the "Standard" type for pressures up to 200 lb., and a heavier pattern called the "Inspector" valve. The shapes and proportions of the seats and regulating lips of both valves are the same. These valves are illustrated in Figs. 7 and 8.

One distinguishing feature of these bevel-seated valves is that the ring by which the blow down is regulated does not surround the edge of the lip of the valve disk to cover the opening at the moment of opening. When the valve is closed, the outer edge of the lip on the disk is always slightly above and clear of the edge of the lip of the seat gallery. The lip of the disk is shaped to obtain the greatest lifting effect from the impact of the outflowing steam.

The regulation of the blow down is effected by deflecting the escaping steam downward inside the lip, against the bottom of the lip chamber, which is drilled with a number of vent holes through which the steam escapes, more or less rapidly, according to the position of the regulating ring. This discharge of steam is added to the main discharge over the valve lip.

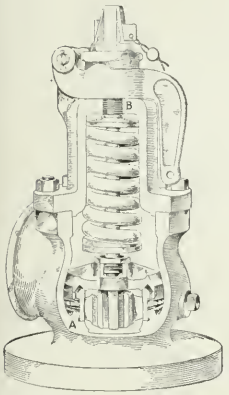


FIG. 7

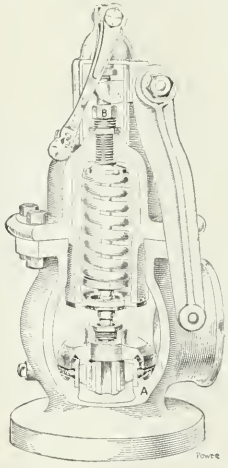


FIG. 8

When the regulating ring is screwed upward close against the under face of the lip chamber it practically closes the vent holes, and all steam is forced over the lip, which increases the pressure in the lip chamber and causes the valve disk to lift higher, keeping the valve open longer. This results in a greater drop in boiler pressure before the valve closes. If the ring is screwed down, and a greater part of the steam escapes through the vent holes, less steam passes over the lip, the valve opens less and closes with less loss of boiler pressure.

The valve disk is mushroom shaped and has a guide much smaller than the diameter of the seat, which is made with a hub about one-quarter the valve diameter, and placed below the level of the valve seat. This prevents cutting of the valve seats, therefore the wear is more uniform around the whole circumference of the seat and the valve will operate longer without leaking and without requiring refacing.

The Standard type of valve, Fig. 7, has the spindle rod slotted near the upper end and a cap and key form a means of lifting the valve disk by the lever. This valve is made either with the spring exposed to the temperature of the exhaust steam or in an inclosed chamber similar to the method employed in the "Inspector" valve, Fig. 8, which is made with heavier walls. This latter valve is adapted for use on saturated steam up to the highest working pressures now available. The spring chamber is drained at the bottom and the lower end of the valve stem moves freely in a hole having sufficient clearance to prevent binding. Valves used with superheated steam are made with steel bodies in either type of valve.

The "Inspector" valve is made with a hinged cap which covers the adjusting bolt and lifting device. When this is in its normal position, with a bolt through it locked in place, it is impossible to change the set pressure of the valve or to tamper with it.

In both valves the spindle rod is provided at its lower end with a steel-inserted nose which gives an effective bearing for the spring pressure.

Each type of valve is fitted with a spring of round steel, the tension of which is adjusted by the head bolt *B*.

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An American Locomobile

At the recent meeting of the Ohio Society of Mechanical, Electrical and Steam Engineers, George S. Cooper, mechanical engineer of the Buckeye Engine Co., read a paper upon the locomobile which they have undertaken to introduce into American practice under the name of the Buckeyemobile.* After describing the unit he said:

Carefully conducted tests have been run from time to time to determine the efficiency with various grades of coal and with modifications of the furnace and grates. Table 1 presents the average results of seven tests run with Pocahontas coal. Column A is the average of three tests run at about 95 per cent. of the rated load. B is the average of two tests at 14 per cent. overload, and C two tests at 36 per cent. overload. Fig. 1 presents the principal conclusions in graphical form. Note especially the flatness of the economy curves demonstrating the ability of the locomobile to handle large overloads with a scarcely perceptible loss of efficiency. While not shown in this series, other tests show that the same valuable characteristic is possessed at underloads. The three-quarter load fuel consumption is within 5 per cent. of the rating and even at half load the coal consumption is less than 20 per cent. greater per horsepower than at rated load.

TABLE I.

	A	B	C
Load, per cent	95.	114.	136
Indicated horsepower	166	199	237
Kilowatts	99 4	121 5	146 8
Rev. per min.	206	209	208
Steam pressure, lb.	209	208	207
Saturation temperature, deg. F.	391	391	390
Steam temp. at throttle, deg. F.	638	673	668
Initial superheat, deg. F.	247	282	278
Hp. exhaust temp., deg. F.	313	353	387
Receiver pressure, lb	13	18	27
L-p. inlet temp., deg. F.	413	432	457
L-p. superheat, deg. F.	169	178	188
L-p. exhaust temp., deg. F.	146	150	162
Feed-water temp., deg. F.	131	132	138
Vacuum (ref'd to 30" Bar.) in hg.	25.6	24.3	24 3
Temp. gases base of stack, deg. F	501	558	578
Total steam per hr., lb.	1626	1970	2420
Steam per i.hp.-hr., lb.	9.8	9 9	10.2
Steam per kw.-hr., lb.	16 35	16 3	16 5
Total coal fired per hr., lb.	192	238	283
Coal per i.hp.-hr., lb.	1.16	1 195	1 195
Coal per kw.-hr., lb.	1.94	1 96	1 93
Boiler and superheater eff., per cent.	76.9	76.6	77 0
Thermal eff. of engine, per cent.	19.8	19 7	19 5
Thermal eff. of unit, per cent.	15.6	15 1	15 0
Heat value of coal, B.t.u.	14,136	14,099	14,215

In comparing the above results with other power-plant data, it should be remembered that the locomobile is essentially a small- or moderate-sized plant. Small steam plants are usually quite wasteful of fuel for several reasons. In the first place small engines are almost always of the high-speed, noncondensing type, using 30 to 40 lb. of steam per hp.-hr. Radiation losses are relatively greater in small plants than in large ones, due to the fact that small boilers, cylinders and pipes expose more surface per pound of steam carried than large ones. To equip a small plant with economizers, condensers, superheaters, etc., is not often commercially feasible since small apparatus of this class is usually much more costly per

*Described in "Power," Sept. 20, 1913.

horsepower than that used in large plants. Fig. 2 is presented to show clearly the effect of plant capacity on economy, and to impress the fact that in the locomobile we possess the means of reducing power costs in a 50- or 75-hp. plant as low or even lower than in the central station with its large units. This fact is further elucidated in Fig. 3 which shows to an accurate scale the distribution of the heat losses and the comparative fuel con-

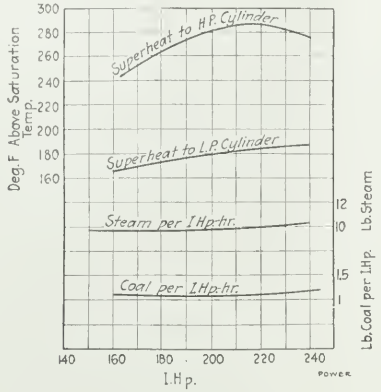


FIG. 1. ECONOMY TEST

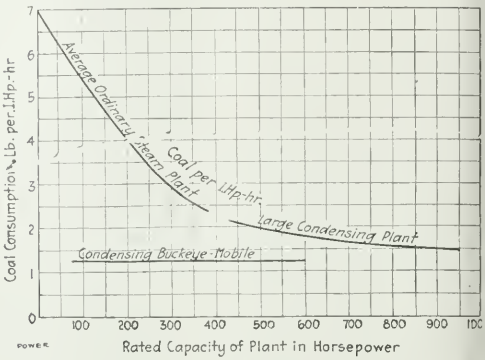


FIG. 2. COMPARISON BETWEEN BUCKEYEMOBILE AND ORDINARY PLANT

sumption of a number of typical power plants. The total length of each diagram, exclusive of the part in broken lines, is proportional to the coal consumed per horsepower per hour. The heavily shaded portion of each diagram is proportional to the number (2545) of heat units actually converted into work per horsepower per hour. The lightly shaded portions at the left represent the boiler-room losses and include that due to incomplet combustion and loss to the ashpit, radiation from boiler and setting, and waste in the hot chimney gas. The smal portions with vertical shading show the heat expende in driving the boiler-feed pumps and other auxiliaries The unshaded sections on the right are proportional t the heat rejected in the engine exhaust, and the length of these sections, measured to the B.t.u. scale, show th amounts of heat available for heating purposes in co nection with noncondensing operation.

The areas inclosed in broken lines represent the he recovered to the boiler by the feed-water heater. A these quantities may be measured with the scale at th bottom of the chart either in B.t.u. or pounds of coal pe hp.-hr. The boiler efficiency in each case is found b

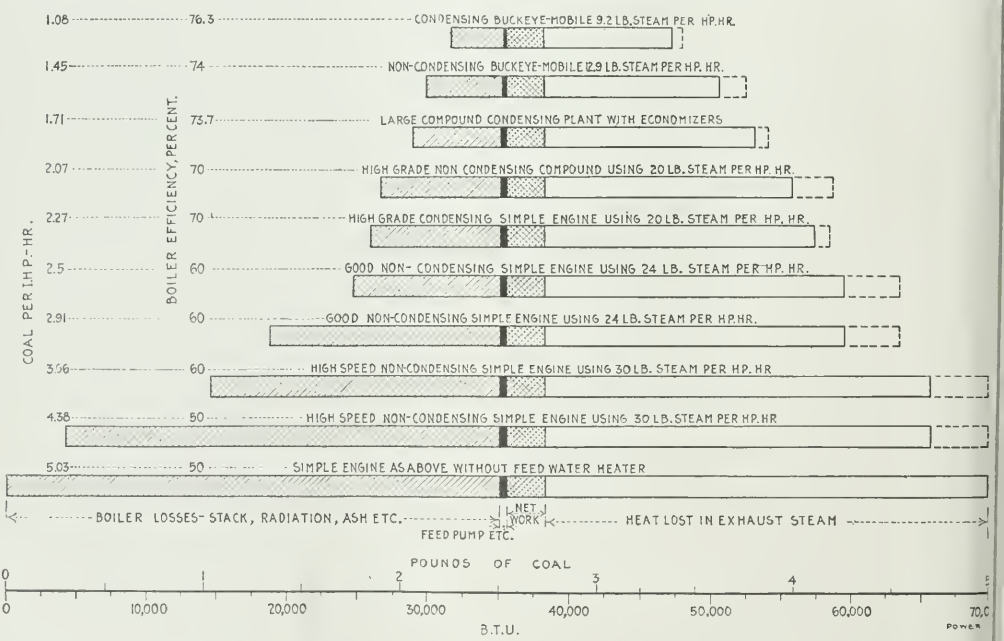

1.08 76.3 CONDENSING BUCKEYE-MOBILE 9.2 LB. STEAM PER HP.HR.
1.45 74 NON-CONDENSING BUCKEYE-MOBILE 12.9 LB. STEAM PER HP. HR.
1.71 73.7 LARGE COMPOUND CONDENSING PLANT WITH ECONOMIZERS
2.07 70 HIGH GRADE NON CONDENSING COMPOUND USING 20 LB. STEAM PER HP. HR.
2.27 70 HIGH GRADE CONDENSING SIMPLE ENGINE USING 20 LB. STEAM PER HP. HR.
2.5 60 GOOD NON- CONDENSING SIMPLE ENGINE USING 24 LB. STEAM PER HP. HR.
2.91 60 GOOD NON-CONDENSING SIMPLE ENGINE USING 24 LB. STEAM PER H.P.HR.
3.56 60 HIGH SPEED NON-CONDENSING SIMPLE ENGINE USING 30 LB. STEAM PER H.P. HR
4.38 50 HIGH SPEED NON-CONDENSING SIMPLE ENGINE USING 30 LB. STEAM PER HP.HR
5.03 50 SIMPLE ENGINE AS ABOVE WITHOUT FEED WATER HEATER
COAL PER I.H.P.-HR.
BOILER EFFICIENCY, PER CENT.
BOILER LOSSES- STACK, RADIATION, ASH ETC.
NET WORK
FEED PUMP ETC.
HEAT LOST IN EXHAUST STEAM
POUNDS OF COAL
B.T.U.
POWER

FIG. 3. COMPARATIVE HEAT LOSSES AND COAL CONSUMPTION OF TYPICAL PLANTS

dividing the sum of the lengths of the portions representing net work and exhaust loss by the total length of the diagram. The "net work" portion divided by the total length equals the thermal efficiency of the entire plant.

Observe that in the case of the simple engine plant at the bottom of the chart less than 4 per cent. of the heat of the fuel is converted into work, while the condensing Buckeyemobile shows an efficiency of 17 per cent., and the noncondensing Buckeyemobile shows an efficiency of 12 per cent.

The data for the third example in the chart (large compound condensing plant) are taken from "Kent's Mechanical Engineers' Pocket Book," 10th edition, page 985. Note that it is a plant of large capacity with fuel economizers and is regarded as one of the most efficient plants in existence and yet it is surpassed in fuel economy by the Buckeyemobile in sizes as small as 100 hp.

The apparatus in the above chosen examples is assumed to be in good physical condition, free from steam leaks or other obvious defects.

Running Centrifugal Fans in Parallel

By L. B. Lent

SYNOPSIS—To lessen the difficulty of operating fans in parallel, the piping should be carefully proportioned, and pitot tubes for measuring velocity head in the discharge of each fan should lead to a common scale board.

When the discharge from two or more centrifugal fans is delivered into a common discharge pipe, these fans are said to be running in parallel. The pressure in each case is that which one machine alone would develop, but the air delivered is the sum of the volumes discharged by each fan.

Running the discharge from several fans into a common main or header seems, at first thought, to be a simple matter of connecting the fans up in this manner; but one has but to try it to discover that operation under this arrangement is impossible except under certain conditions. The writer's experience may be typical and serve to point out the essentials of proper operation under the conditions.

Two large single-stage turbine blowers were connected to a discharge main, as shown in the illustration. When first installed, one fan was sufficient to furnish the necessary air, at about 2 lb. pressure, to serve the oil burners in a number of metal-heating furnaces. The other fan served as a reserve unit and they were run alternately. A rapidly increasing demand for air made it necessary to run both fans together and, eventually, to add a third.

It was only necessary to start the second fan, the first one being already in operation, to discover that it would not deliver any air and that the first fan was actually blowing air right back through it. These two fans were of the same size, direct-connected to similar direct-current motors and ran at the same speed.

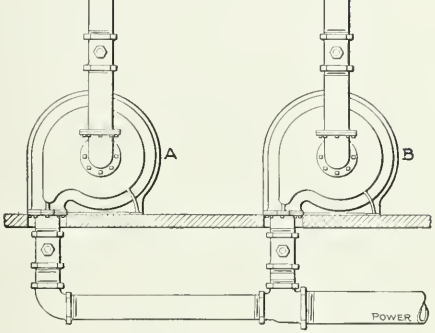
An analysis of the action of a centrifugal fan and the flow of air in pipes will show under what conditions centrifugal fans may be operated in parallel. Three facts must be clearly conceived and borne in mind. They are:

1. For a given fan, the air pressure generated depends upon the peripheral velocity of the wheel or runner.

2. This pressure can be generated and maintained within the fan casing whether air is being discharged or not by running the fan up to speed with the discharge valve closed.

3. The total head of air in motion is the sum of two separate heads—the static head and the velocity head—the sum being called the dynamic head.

When air is under pressure in a closed vessel, a receiver for instance, its pressure may be measured by a pressure gage, or if light, by a water column. This pressure existing in the quiescent gas is called the static pressure, and often its static head, being commonly expressed in pounds per square inch, inches of mercury or inches of water. When air under pressure is flowing in a pipe, the velocity of flow is due to a drop in pressure and is proportional



Fans in Parallel

to a certain difference in pressure. The head equivalent to the velocity is commonly called the velocity head and sometimes the kinetic head. The sum of the static and the velocity heads is the dynamic head.

When a centrifugal fan is started and brought up to maximum speed, with the discharge pipe entirely closed off, the air in the casing is whirled around with the fan blades and the static pressure measured in the discharge pipe is that due to the linear speed of the blades. With no air being delivered, the fan will absorb only a small amount of power. It is only when air is actually discharged against a resistance that more power is absorbed by the fan. When air is moving in a pipe, the velocity with which it is moving is equivalent to a certain pressure, and the velocity head is easily and accurately measured in units of pressure by means of the pitot tube.

An examination of air tables, referring to fan work

will show that the velocity component is a considerable part of the total pressure. It is the velocity head, due to the inertia of the moving air, which must be dealt with when running fans in parallel.

Referring to the illustration, when fan *B* was running and delivering air at a static pressure of 2 lb., fan *A* was started and brought up to the same static pressure as fan *B*, but not a cubic foot of air did it deliver. On the contrary, air was actually flowing out of the intake pipe of fan *A*. The reason was, that the air being delivered from *B* was flowing at some velocity instead of being at rest and, consequently, had a velocity head in addition to a static head of 2 lb. If the velocity head be assumed at ½ lb., then the total or dynamic head of the discharge from *B* is 2½ lb. Since no air is really flowing from *A*, even though the wheel be running at a speed sufficient to generate a static pressure of 2 lb., the total head (static and velocity) at the fitting below *B* is greater than the total head (static only) existing at the outlet valve of *A*. As soon as the outlet valve of *A* is opened, the greater pressure will actually force air back through fan *A*. To make *A* deliver air, it is necessary to throttle the discharge from *B* until the dynamic head at *B* decreases to an amount equal to or slightly less than that at *A*.

Some form of measuring instrument must be used to indicate the discharge from each fan, so that it may be positively known that each fan is delivering its proportion of the amount of air flowing. A simple instrument for such use is the pitot tube, arranged as a differential gage, and so indicating velocity only. There will always be a flow if a velocity is indicated. And if pipe sizes are proportional to the volumes flowing, the velocities from each fan should be equal. If, therefore, the readings from the pitot tubes from the discharge sides of two or more fans are the same, it is quite certain that these fans are delivering their proportional amounts of air.

When fans of different sizes and speeds are connected to deliver air to the same main, the problem of their parallel operation becomes more complex, but is based on the same equality of total or dynamic heads.

Starting up an idle fan and putting it into the line is, of course, the troublesome part, for, until air is actually flowing through and away from the fan, it has no velocity head. If it can be speeded up so that its static head alone is equal to the static and velocity heads of the fans already in operation, then the higher static pressure will start the air flow and the speed must then be adjusted until the dynamic head is the same as that under which the other fans are running.

When the speed of the fan cannot be raised above that of the running fans, which is the more common condition of operation, then the dynamic head of the running fans must be reduced to equal that of the static head of the fan being put onto the line.

This operation, when there is more than one fan already running, is not an easy performance. Paralleling two fans is easy but paralleling three is not. The usual type of inlet and discharge valve furnished by the makers is some form of butterfly valve or slide gate, and a fine adjustment of the former is a work of art. A pitot tube on the discharge side of each fan with the gages so connected that the operator may read all from one point seems to be the most desirable arrangement, when it is necessary to parallel fans.

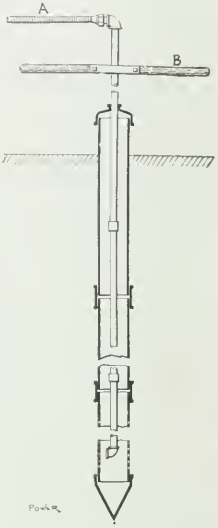
The usual method is to adjust inlet or discharge valves and it is sometimes necessary to move fast from one fan to another, to get the fans together and to keep them together after they are in.

When positive blowers or compressors are discharging into the same line, the conditions are quite different and, up to the limit of the possible discharge pressures developed, each machine will discharge its proportionate share of the air.

Cleaning Driven Wells

By J. B. Proctor

Much of the water used in our plant is obtained from 2-in. driven wells of depths from 45 to 60 ft. The screen or perforated pipe at the bottoms of these wells would clog up every five months and we at the plant had to remove the obstruction. The method of cleaning was to draw up the well pipe, put on new or old and clean screens and redrive the pipe. This was a troublesome and expensive operation.



Ready to Clean Driven Well by Steam

To lower the cost of cleaning and also reduce the consequent troubles, the writer devised the cleaning outfit shown. A ⅜-in. pipe longer than the well pipe and with an elbow on each end is connected to a steam pipe by the steam hose *A*. To the ⅜-in. pipe a wooden clamp *B* is fastened. A platform is located over the well to assist in putting in the ⅜-in. pipe. When the pipe is in place and the top of the well closed, steam at boiler pressure (100 lb.) is admitted to the pipe. The pipe is then raised, lowered and turned by men on the platform holding the clamp. The wells, after being cleaned, give nearly as much water as a new well.

Electricity to Operate the Panama Canal—The machinery for operating the gates, dams, fender chains, pumps, etc., will be electrically driven; the ships will be towed through the locks by powerful electric locomotives, and electric energy will be utilized entirely for the permanent machine shops, for the dry-dock, for the coal-handling plant, for wharf cranes, and for a number of other purposes. The locks and near-by towns will be electrically lighted, and the relocated Panama railroad will possibly be electrified. Two large power stations and many miles of transmission circuits will be required for the generation and transmission of the power to more than one thousand electric motors which will be required for the operation of the canal. The water power is obtained from the Chagres River water shed; Gatun Lake, having an area of 165 square miles, offering excellent storage facilities. A 7500-kw. hydro-electric generating station, which will supply the power under normal conditions, is being built at the spillway of the Gatun dam. The present steam-turbine station at Miraflores, which has been used during the construction of the canal, will, however, be retained and held in reserve to tide over either shutdowns or low-water periods of the Gatun station, the intention being to tie together the two plants by a high-tension transmission line. Besides the above, hydro-electric power will be extensively used for lighting purposes along the canal, and possibly in connection with the fortifications which are being planned.—"Engineering Magazine."

ELECTRICAL DEPARTMENT

The Induction Motor—V

By F. A. Annett

A motor constructed similar to the induction motor shown in Fig. 6, Part 1 (page 536, Oct. 14 issue) and provided with but one winding, if connected to a single-phase circuit, could only produce a simple alternating magnetism, and not a revolving magnetic field. The action would be similar to that of a transformer, the stator winding acting as the primary and the rotor acting as a short-circuited secondary; very heavy currents would be set up in the rotor, the primary taking a large lagging current from the line. The current in the rotor is of such a direction and position that the motor will develop very little torque, but if given a start by hand would gradually come up to speed in whichever direction it is started, then the load may be applied and the motor will behave similar to a two- or three-phase motor. As the speed of a single-phase motor approaches synchronism the combined action of the stator and rotor currents is to produce a rotating magnetic field similar to that produced in a motor with two or more windings supplied by two or more alternating currents displaced in phase. The most prominent difference between the single-phase and polyphase induction motors is the inability of the single-phase motor to start.

If a single-phase motor is to be made self-starting, some means must be provided for producing a revolving magnetic field, and for doing this numerous devices have been produced. In the design of single-phase fan motors and motors of similar size used for power purposes little trouble is experienced, but in large motors where efficiency and other operating characteristics are of primary importance the problem assumes a different aspect.

Shaded-Pole Motor

One of the simplest methods of producing a revolving magnetic field for bringing a single-phase motor up to speed is that which is known as the "shaded pole." The stator of this type is shown diagrammatically in Fig. 43. The field structure is built up of laminated iron with pole projections similar to a direct-current machine with a slot cut in the pole face parallel to the axis of the rotor, as shown in Fig. 44. This slot is sometimes cut through the center of the pole face and sometimes to one side. The field coils are similar to those in the direct-current machine and all are connected in series as shown. A rectangular copper stamping is placed around each pole tip in the slot, as shown in Fig. 44. In some cases this copper stamping is replaced by a number of turns of low-resistance wire, the two ends of the coil being joined to make a closed circuit; these are called shading coils. The rotor of this type of motor is a simple squirrel cage. The action of the copper stamping or shading coil is as follows:

If these field coils were connected to a single-phase circuit they would have a current set up in them first in one direction and then in the other. This alternating current sets up an alternating magnetic field through the field structure and rotor. The field coils will act similar to the primary of a transformer and the shading coils like the secondary. Since the shading coils are of very low resistance and short-circuited they will have heavy currents set up in them that will oppose the change in the magnetic flux set up by the main coils. Consider the current increasing in value through the coils in a direction so as to produce alternate north and south poles, as shown. As the current increases in value it will

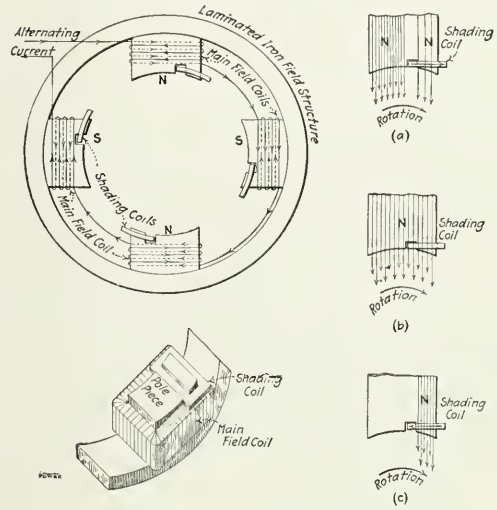


Fig. 43. Stator of Shaded-Pole Motor
Fig. 44. Detail of Shaded Pole
Fig. 45 (a), (b), (c). Flux Distribution Due to Shaded Pole

set up an increasing magnetic flux that will induce a current in the shading coils in opposition to the current in the main coils, as indicated by the arrow-heads. Therefore, the magnetomotive force produced by the shading coil will be in opposition to that produced by the primary coil. This will distort the flux away from the pole tips with the shading coil over to the opposite pole tip. Such a condition is represented in Fig. 45(a), but the flux will continue to increase through the pole tip with the shading coil until the exciting current has passed through a maximum and decreased to a point just sufficient to maintain the flux in the polepiece equal to that in the part surrounded by the shading coil. At this point the magnetic flux through the shading coil is at a maximum and the current in the shading coil is zero; Fig. 45(b) shows this condition. As the flux in the main part of the pole continues to decrease, the current in the shading coil reverses in direction and sets up a magnetomotive force

...is made to prevent any change of lines of force through ...e shading coil so that when there is no flux in the main ...rt of the pole there will be considerable field within the ...hading coil, as shown in Fig. 45(c); therefore, the north ...ole has shifted from the main portion of the polepiece ...o that which is within the shading coil, likewise with ...he other poles. As the current in the line reverses north ...oles are interchanged with south. It will be seen that

FIG. 46. ALTERNATING-CURRENT CIRCUIT WITH RESISTANCE AND INDUCTIVE REACTANCE

FIG. 47. RELATIVE VALUES OF CURRENT AND E.M.F.

...he poles are continually shifting around in the direction ...f the shading coil, producing a truly revolving field. ...A rotor placed in this field would be carried around with ...t just as in a polyphase motor. This type of motor is ...sed chiefly for fans and is usually built with four or six ...poles, although it may be constructed with any given ...number, depending upon the speed required. This motor ...oes not operate satisfactorily in large sizes on account of ...ts low efficiency, low starting torque and other operating ...characteristics.

From the foregoing it was seen that the rotor turns across the polepiece in the direction of the shading coils. To reverse the direction of rotation it will be necessary to place the shading coil on the opposite pole tips, but in some cases this cannot be done for the shading coils do not always pass through the center of the pole face. If the bearings are interchangeable the rotor may be turned end for end, this will be the same as turning the entire field structure around, which would bring the shading coils on the opposite side of the polepieces when viewed from the same end of the rotor as before. Where this cannot be done it will be necessary to remove the lamin-

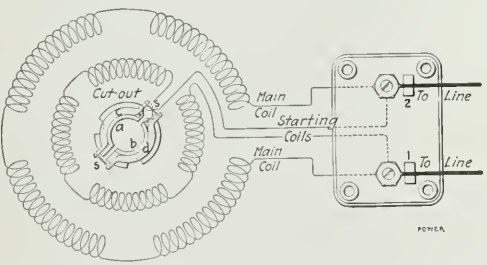


FIG. 48. REPRESENTING SPLIT-PHASE WINDINGS OF EMERSON MOTOR

...ated field structure from its shell and place it in the opposite way.

SPLIT PHASE

Another method that is used in a great many different forms for starting single-phase motors is that which is known as phase splitting. It is well known that when an alternating current divides between two branches of a circuit of unequal resistance and reactance there is a phase difference between the currents in the two branches; that is, the current in one branch lags behind that in the other, depending upon the resistance and reactance in the two circuits. This condition is represented in Fig. 46, where R is a resistance of low reactance and L is an inductive reactance connected in parallel with R to a single-phase alternating-current circuit. Let the curve A, Fig. 47, represent the e.m.f. of the circuit. An alternating current will flow in the circuit R approximately in step with the impressed e.m.f. since the reactance of R is very low. Let this current be represented by the curve B. Since the reactance of L is high, an e.m.f. will be induced in it, which will oppose any change in the value of the current in the circuit, therefore the current will lag behind the applied e.m.f. and may be represented by the curve C. From this it will be seen that the current in circuit R is at a maximum when the current in L is at a low value and *vice versa;* therefore, the currents in R and L approach the condition of the currents in a two-phase

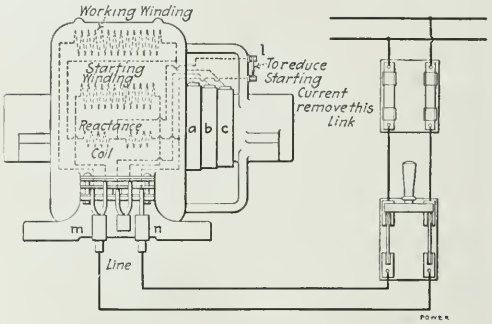


FIG. 49. WINDINGS OF HOLTZER-CABOT MOTOR

circuit which are 90 deg. apart and are represented by the curves in Fig. 5, Part 1 (page 535, Oct. 14, 1913, issue).

SPLIT-PHASE MOTOR

If an induction motor is constructed with two windings, one of high resistance and one of low resistance, these windings being spaced as in the two-phase motor, and the two windings connected in parallel to a single circuit, they will produce a revolving magnetic field as explained in Part 1. This type of motor is called a split-phase motor.

Fig. 48 represents the windings of an Emerson single-phase motor that is accelerated by the split-phase method. The main coils are made up of many turns of coarse wire which occupy about three-quarters of the stator slots, the two ends of which are connected direct to the line terminals. The starting winding which consists of many turns of fine wire occupies about one-quarter of the slots, one end of which is connected to the line terminal (1), and the other connected to the line terminal (2) through two segments *a* and *b*. These two parts are stationary and are mounted on the inner end of one of the bearing housings and are insulated from each other and their support. When the motor is at rest segments *a* and *b* are short-circuited by the semi-circular contacts *c* and *d* which are mounted on the rotor and held in contact with segments *a* and *b* by the springs *s*, as shown.

At starting, the conditions are similar to those explained for Fig. 47. The current in the main

winding lags farther behind the electromotive force than the current in the starting winding, thus producing an imperfect form of revolving magnetic field which gives the motor sufficient torque to bring it up to speed. When the rotor has reached about 75 per cent. full speed the contacts *c* and *d* are thrown off segments *a* and *b* by centrifugal force. This leaves the starting winding open

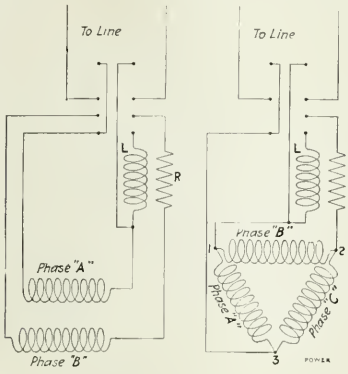


FIG. 50.

FIG. 51.

METHOD OF STARTING TWO- AND THREE-PHASE MOTORS

circuited, and the motor operates on the main winding. If the motor is to be started under load the rotor is arranged to revolve freely on the shaft. When it has attained about 85 or 90 per cent. normal speed the shaft and rotor are locked together by a clutch, in this way these motors are enabled to start under full load. To reverse the direction of rotation cross either the leads of the starting or running winding. This type of single-phase motor is built by several electrical manufacturers.

Fig. 49 shows diagrammatically a Holtzer-Cabot split-phase motor that is built in sizes from 1 to 5 hp. In addition to the main and starting windings, as already referred to, an additional external inductive reactance, mounted in the base of the motor frame, is connected in series with the main or working winding at starting. This reactance causes a greater phase displacement between the currents in the starting and main windings with a corresponding increase in starting torque. This type of motor will start under full load without any automatic rotor clutch. Three slip rings *a*, *b* and *c*, which are insulated from each other, are mounted on the rotor shaft through which the main and starting windings are connected by brushes. At starting, slip rings *a* and *b* are connected together through a switch in the rotor. This allows the current from the line to flow from terminal *m* through the working winding and the reactance coils to the opposite terminal *n* of the line, also from terminal *m* through the starting winding and the slip rings *a* and *b* to the line terminal *n*. When the motor has attained about 80 per cent. full-load speed the centrifugal switch opens the circuit between slip rings *a* and *b* and closes that between slip rings *a* and *c*. This cuts out the starting winding and short-circuits the reactance coils; then the main winding is connected direct to the line. When necessary a link *l* is used to short-circuit one section of the reactance. This allows the motor to take a larger starting current from the line which increases the starting torque. In sizes of less than 1 hp. the reactance coils are disposed with and only two slip rings are used which are radial and are mounted against the end of the rotor with brushes that are parallel with the shaft.

POLYPHASE MOTORS ON SINGLE-PHASE CIRCUIT

A two-phase motor will start when the currents in the two stator windings are less than 90 deg. apart, likewise a three-phase motor will start when the three currents in the three stator windings have a phase displacement other than 120 deg., although the starting torque becomes less and less as the phase displacement changes. Two-phase motors may be started on a single-phase circuit by connecting a resistance or an inductive reactance in series with either phase. This method can be improved by connecting a resistance in series with one phase and a reactance in series with the other phase. Fig. 50 shows the connections for doing this through a double-pole double-throw switch. When the switch is in the down position a reactance *L* is connected in series with phase *A* and a resistance *R* in series with phase *B*. The reactance *L* increases the phase displacement between the e.m.f. and the current in phase *A*, while the resistance *R* decreases the phase displacement between the e.m.f. and the current in phase *B*, thus causing a phase displacement between the current in phases *A* and *B* and producing an imperfect form of revolving magnetic field which will develop sufficient torque to bring the motor up to speed. Then the switch may be thrown to the up position, which connects phase *A* direct to the line and phase *B* is cut out of circuit.

A three-phase motor may be brought up to speed on a single-phase circuit by connecting two of the motor terminals to one side of the line through a resistance and reactance and the third terminal direct to the line. Fig. 51 shows the connections for doing this through a double-pole double-throw switch. When the switch is in the down position the motor terminals 1 and 2 are connected

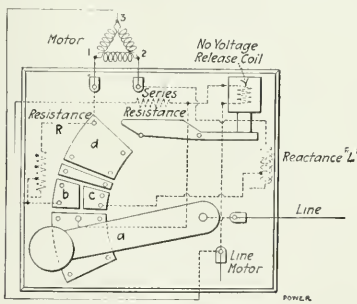


FIG. 52. G. E. STARTER

to the same side of the line through a resistance *R* and reactance *L* respectively, and terminal 3 is connected direct to the line. This gives a phase displacement to the current in the three stator windings which is sufficient to start the motor under no load. After the motor has been brought up to speed the switch is thrown to the up position, thus cutting out the resistance and reactance and connecting terminals 1 and 3 direct to the line; then the motor is operating as a single-phase motor and the load may be applied. A three-phase motor operating un-

this condition will only have about two-thirds the capacity of its three-phase rating and has its maximum starting torque when the starting resistance and reactance are equal.

The General Electric Co. builds a single-phase motor which is started by the foregoing method. The starting resistance and reactance are mounted in a suitable starting box, shown in Fig. 52, connected to the stator windings which are connected in delta and are the same as in a regular three-phase motor. At starting the arm *a* is raised to a position so as to rest on contacts *b* and *c*. This connects the motor to the line through the resistance *R* and reactance *L* which is the same condition as in Fig. 51. After the motor has attained the proper speed, arm *a* is raised to position *d* and is held in this position by the no-voltage release coil. Arm *a* is made interlocking in such a way that when it is raised to the starting position it cannot be raised any farther until first dropped back slightly to release the lock and then raised quickly to the running position. This prevents the attendant from raising the arm to the running position before the motor has had time to accelerate. The rotor is of the regular squirrel-cage type and is arranged so that at starting it revolves freely on the shaft. After attaining approximately full speed the rotor is locked to the shaft by means of an automatic clutch. These motors are built in sizes from ¼ to 15 hp. The 10- to 15-hp. starters are provided with taps on the starting resistance and reactance so that the starting torque can be changed.

System of Tallying Truck Loads

By Ernest Giles

Counting truck loads of wood in the grinding room of a pulp mill, although a simple task, involves the personal element so much that the figures are seldom reliable and as production is checked against the amount of wood ground it is necessary to have an accurate count. There is at present being installed in a mill in northern New York a system of counting loads that is novel and at the same time simple, but above all practically fool proof, and will wipe out the personal element which has always been unreliable in the past. This system, although designed primarily for a pulp mill, could be used for other purposes, such as carloads of coal.

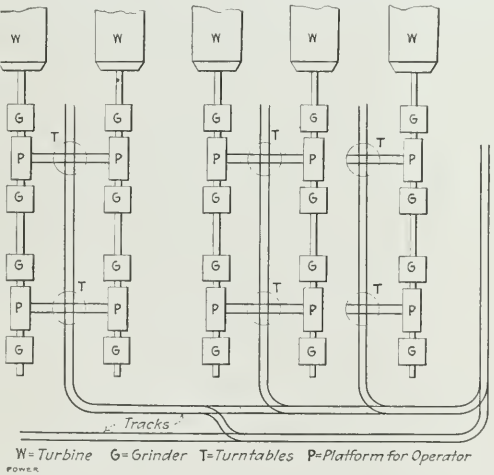


Fig. 1. Layout of Plant

The mill of which I write has 20 grinders, one grinderman taking care of two grinders, and working on eight-hour shifts. It is desired to know not only how many cords of wood are ground but how many each man grinds.

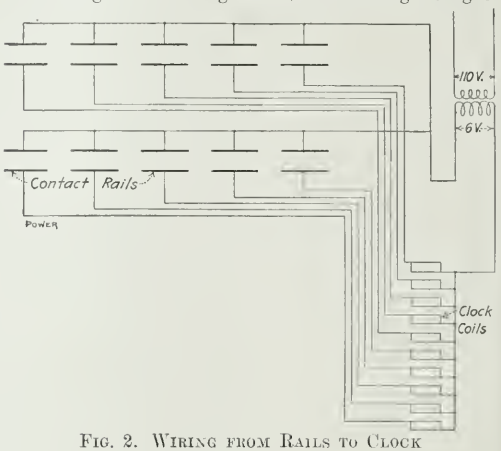


Fig. 2. Wiring from Rails to Clock

The grinder room is laid out as shown in Fig. 1 and is equipped with a system of rails and turntables going to all grinders. Wood is loaded onto trucks holding one-half cord and is pushed over the rails onto the turntables and turned directly onto a short siding, where the operator handles the two grinders.

The short rails at the sidings are insulated from the turntables and from each other, and form the two sides of an electric circuit which is closed by the wheels of the truck, thereby furnishing an excellent way of telling not only the time at which a load arrives but also how long it stays there and how soon a new load is placed.

Electricity for energizing the rails is supplied by a small specially designed transformer giving six volts at the secondary winding, this voltage having been decided on after a series of tests under working conditions.

All wiring is in conduit and is run under the floor in ducts, and the connections to the rails are made from below for protection. The wire used is standard No. 14 rubber covered, and is installed with the same degree of care as if it were used for lighting or power service.

The recording clock used follows standard practice in the arrangement of chart and pens, but is designed especially for use on low-frequency alternating current and uses solenoids for working the pens in place of ordinary magnets. Tests proved that magnets, as ordinarily built, gave a chattering movement of the pens unless very carefully adjusted, and any attempt to make the movement of the return to the position of rest (power off) positive, made the chattering worse, as the pens would necessarily be returned by spring pressure. However, the chattering was entirely overcome by using solenoids, the cores of which are so arranged as not to produce any movement of the pens other than to draw them over the chart and hold them there as long as the current is on the coils.

Reference to Fig. 2 will show the wiring scheme, which is the same as that used on an ordinary annunciator.

HEATING AND VENTILATION

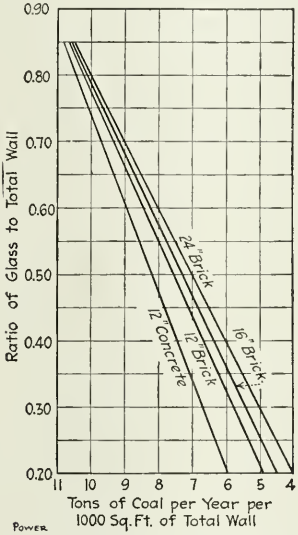
Coal to Heat Factory Buildings

By James D. White

There are various opinions as to the relative merits of the isolated plant and the central station. It is not the intention of the writer to take sides in this matter but rather to present some facts regarding the fuel requirements of factory buildings which may be of use in forming an opinion for any particular case.

Accurate information as to the power required for a plant is generally available. It is just as necessary to know the amount of steam required for heating, but information on this point is usually lacking.

About 80 per cent. of the heat of the steam at the pressure of the exhaust is available for heating. Knowing the pounds of steam required per hour to drive the engine in any plant it is easy to calculate the amount remaining for heating.



Coal per Season for Different Thicknesses of Wall

For the conditions found in the New England States about 65 lb. of coal are required per square foot of direct radiation for the heating season. Buildings heated by the fan system will vary in their fuel requirements from those heated by direct radiation, depending on the amount of air supplied from the outside.

The curves accompanying this article are based on standard factory construction. An amount of radiation is provided to heat the buildings to 65 deg. in zero weather. Values are given for buildings with 12-, 16- and 24-in. brick and 12-in. concrete walls.

The term "equivalent roof" is defined as a square foot of roof surface with the same transmission rate as a square foot of wall surface. A large majority of factory buildings are covered with a tar and gravel roof on 2-in. plank. In this case, 1 sq.ft. of roof equals 1 sq.ft. of 12-in. brick, 1.21 sq.ft. of 16-in. brick, 1.57 sq.ft. of 24-in. brick and 0.70 sq.ft. of 12-in. concrete. For roofs covered with slate or tile, suitable allowances should be made.

Reduce the square feet of roof surface to an equivalent number of square feet of wall surface having the same transmission in B.t.u. per hour. Add this result to the square feet of vertical wall to obtain the total wall surface. Walls adjacent to a heated building should be omitted as there will be no transfer of heat through them. Find the ratio between the square feet of glass surface and the square feet of total wall surface for the building under consideration. At the point where this line intersects the curve for a given thickness of wall surface drop a vertical to the lowest horizontal line of the chart and read tons of coal per year for 1000 sq.ft. of wall surface.

In case there are several thicknesses of wall in the same building, find the values for each different thickness and combine the results. It is evident that buildings with little leakage or those having an automatic system of temperature control will use less fuel than the average value previously given. On the other hand, buildings with large doors which are open to transfer manufactured products will require more fuel than would be indicated by the curves. In such cases good judgment will be required to modify the values given.

It is the desire of the writer that engineers having accurate data on the fuel requirements of their own buildings will compare their results with the method given above. Particular attention should be paid to any special features of the plant that would tend to show the reasons for the difference in values. In this way much valuable information may be given regarding a subject that at the present time is more or less in doubt.

A Combination Steam and Hot-Water Heating System

By A. P. Connor

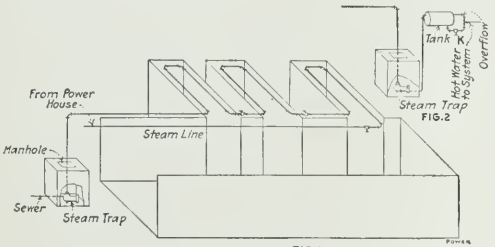
There are many occasions arising in daily practice, where a combination steam and hot-water system using the same piping and the same heating medium is not only mechanically desirable but would increase the efficiency of the plant. Such a system can be readily adopted in many installations without involving appreciable labor or cost, as was done in the case to be described.

In the particular instance which the writer has in mind, a steam main ran from the power house to a series of buildings, over 1000 ft. away, and supplied heat for various purposes and in various degrees. The method originally employed was to use live steam and exhaust into the sewer, the radiation in the various buildings be-

proportioned to its heating requirements and controlled by valves. This system was satisfactory as far as heating was concerned, but the amount of steam rising out of the sewer manholes in the vicinity of the discharge from the heating system of these buildings made an undesirable spectacle in addition to the waste of energy. The engineer in charge, who it may be said was not responsible for the original layout, decided something had to be done, and that without any outlay because no funds were available.

On investigation he found the following situation: As shown in Fig. 1, the steam mains to the buildings near the end of the lines were run close to the ceilings and dropped to the radiation in the buildings in series, thence going through a steam trap to the sewer. The water sent through the trap being hot, created a lot of vapor in the sewer which came out through the various manholes and was especially conspicuous on damp or cold days.

The trouble was remedied by procuring a tank, inserting it horizontally in the steam line close to the ceiling and connecting a steam trap, as shown in Fig. 2. The steam trap collected the water from the heating system



up to that point and when operated raised the water to the tank in the steam mains, a head of about 12 ft. The water was allowed to collect in the tank until it was several inches deep, and then the operator turned on the valve K just sufficiently to let a uniform and constant quantity of water into the system beyond the tank. Sufficient hot water was supplied to keep the system at a desirable temperature and the head given by the position of the tank produced a positive flow. The valve at the end of the line was opened to let the water into the sewer in the same proportion as the hot water entered. An overflow pipe was also provided on the tank to act in case the valve got stopped up or did not let water flow through in sufficient quantity.

The water in the first building heated by hot water was at the boiling point to begin with and the general temperature of the building was high. The next building was heated to the desired temperature but the average temperature of the water was about 60 deg. lower than in the first building. In the third building the temperature of the water was still lower and on leaving the system was barely warm. This eliminated the vapor trouble originally experienced.

It is needless to add that the efficiency of the system was increased, and no difficulties of note were experienced in its operation. The cost of making the changes was practically nothing, owing to the fact that a tank was available at the time, the fittings were in stock and the regular employees of the plant did the work. It may be added that later on all of the water was returned to the boilers by means of a pump. A suitable length of 1½-in. pipe was run underground and a slight change made in the connections at the sewer.

The results produced by these later changes were a saving in water, an elimination of boiler-scale troubles and oxidization, and an appreciable saving in coal. The steam-hot-water combination has been used a number of years and is still in daily service.

❖

Cost of Heating and Power-Plant Apparatus

The article by W. J. Downing in the Nov. 18 issue of POWER under the above title contains much useful information. While most of it appeals to the writer as being sufficiently accurate for estimating probable costs, yet some of the items are excessively high and might deter an embryo designer from using the apparatus considered. Thus under the heading "Radiation," pipe-coil heaters for fan systems are estimated at 45 to 50c. per sq.ft. of surface. In my experience this should be from 24 to 45c. per sq.ft. of surface. This price includes the complete casing and fan connections, the low price being for coils about 7x10 ft. and the higher prices of coils down to 3x6 ft. Now the designer using Mr. Downing's figures would be justified in using cast-iron heaters exclusively at 25c. per ft., although as a matter of fact under certain conditions pipe coils are a better proposition.

Shaking grates instead of costing $5 to $6 per sq.ft. of surface, can be installed for from $3.75 to $4.75 per sq.ft. Open feed-water heaters, good for 10-lb. pressure, complete with oil separator and grease trap, can be bought for about $1 per horsepower as low as the 400-hp. size, and for 75c. per hp. in the 1000-hp. size.

Under the heading "Ventilating Apparatus," steel-plate fans are estimated at $10 to $13 per 1000 cu.ft. at ¾ oz. pressure. This again is far too liberal, $7 to $10 being quite safe.

Galvanized-iron work is estimated at 15c. per lb., which is excessive for average factory work, as 10c. per lb. in place will cover a first-class job where local help can be used. Only recently we let a 5-ton job at about 6c. per lb., but we realize that this is an exceptionally low figure.

Electric-light wiring is estimated at $6 per outlet. For dwellings this is too high, $2 per outlet is a safe figure.

All the prices given by the writer are based on actual quotations given this year and so are perfectly reliable.

In his article, which was short, considering the ground covered, Mr. Downing could not go into details as to what was included in his prices. This may account for the difference between his figures and mine. However, the difference is great enough to warrant attention being called to the fact that in several cases Mr. Downing's estimates are too liberal and thus misleading. They would be even more liberal if the contractor's 10 per cent. were included, as it is in the writer's quotations.

Syracuse, N. Y. A. ROBERTSON.

❖

Remuneration of Electrical Engineers—Anyone who keeps closely in touch with the developments in al branches of the electrical industry cannot fail to be an optimist regarding its future. This is the age of electricity. The demand for men trained to make available its beneficient powers for the service of society is bound to increase. For the best results of all a healthy balance of the demand and supply of men so trained is needed.—"Electrical Review."

EDITORIALS

The Elevation of the Fireman

For years the steam engineer has made the engine room the locus of his activities, and the engine the principal object of his solicitude. Even here the selection has too often been determined by the expected performance of the engine in pounds of steam per unit of output rather than the ultimate economy of the plant expressed in money per unit of production as influenced by the standing charges, use-factor, etc., but that is another story. What we want to emphasize now is the still persisting proclivity to direct one's efforts for betterment to the limited possibilities of the engine room; while the conditions and operation of the boiler room, rich in possibilities of saving beyond anything which continuous effort in the engine room can possibly effect, receive but desultory attention and are left in the hands of the poorest paid and least intelligent of the operating force.

When the engines have been selected, their valves properly set, and provision made for their proper lubrication the exercise of effective supervision is confined to an intelligent adaptation of units to load and to the keeping of the engines in proper condition with regard to packing, valve setting, etc. There is little that one can do in the engine room beyond this that will have any bearing on the cost of the power produced. In the boiler room the conditions are quite otherwise. The most effective normal condition is more difficult to arrive at, and once determined upon is more difficult to maintain. Adjustments instead of being good for months are good for minutes, and a high degree of skill must be constantly applied to conduct the process of converting the energy latent in the fuel into a form in which it is available for power production.

In this part of the plant more than anywhere else the human factor is predominant. Months of study and thousands of dollars of investment are expended upon the efficiency of the engines and apparatus, but how much attention is given to the efficiency of the men?

The process of combustion is a complicated and interesting chemical one. A man who understands it and applies his knowledge may easily do the same work on ten per cent. less fuel, and save twice his wages, while a man in responsible charge of the whole steam-generating plant may easily raise its efficiency from the usual sixty to seventy-five or eighty per cent.

The trouble has been that men with the education, ability and spirit which would make them successful in this work will not work under the conditions of the ordinary boiler room, nor for the money which the ordinary owner or manager is willing to pay for what he has been accustomed to regard as a laborer's job.

With the increasing estimate of the possibilities of saving which the boiler room offers, the lightening of the manual labor by means of conveying machinery and mechanical stokers, the increased interest which comes from the scientific study of the boiler-room processes, the use of instruments requiring as high a degree of skill at least as any used in the engine room, it is reasonable to suppose that the time is near at hand when the management of the fire room will pass out of the hands of the illiterate stoker, and will attract a higher order of man, who will find nothing undignified in applying his knowledge of boilers and furnaces, and baffles, and rates of combustion, and flue gas, coal and ash analysis, to saving a quarter of the coal which is burned in the big plant, and that he will receive a remuneration commensurate with the service which he renders and the saving which he effects.

The papers of J. W. Parker, of the Detroit Edison Co., upon "The Operation of the Large Boiler Units at the Delray Station" of that company and especially that of Prof. Walter N. Polakov upon "Task Setting for Firemen," both read at the recent meeting of the American Society of Mechanical Engineers, are replete with suggestions of the possibilities which lie in this direction.

Substitutes in Emergencies

Continuous service is the prime consideration in any power plant, large or small. Economical operation is secondary to continuous service.

Power-plant apparatus is subject to disorders even when reasonably well cared for, but let the attentiveness of the operator become lax and the liability to accidents productive of service interruptions becomes proportionally greater. Not long ago one of our engineer friends related with justifiable pride how the central-station plant he had operated had not, in nine years, suffered a service interruption that was due to disorders of apparatus or machinery inside the power house. He attributed this to the frequent and thorough inspections given equipment and to the practice of lifting by hand each safety valve and of inspecting the turbine emergency stop just prior to the peak-load periods, which come in the late afternoons. It is this unfailing attention to detail that reduces emergencies to a minimum.

Despite the most careful observation and inspection of equipment, conditions arise that make it impossible to operate the plant without resorting to unusual measures. It is the ability, the resourcefulness, to meet such conditions that makes a man valuable.

We recall the case of a plant in Baltimore which made use of the boilers in a large steamboat to furnish steam when its own were suddenly put out of service. A contemporary criticized the authorities of the Richmond Light & Power Co. for not making use of a similar expedient when its plant was out of service for five days, due to a boiler explosion. Perhaps no one in authority thought of this substitute. This is not a good excuse, however, for the Baltimore incident received adequate publicity.

During the floods in the Middle West last spring many interesting emergencies arose. One plant was unfortunate enough to have the motor driving the condenser-hot-

pump completely disabled. To operate the turbine noncondensing would have meant using all the coal in the bunkers in a few days, with no indication of getting more, as over a 1000 ft. of the railroad siding to the plant was washed away. The dry-air pump was made to handle the condensed steam as well as the noncondensible vapors. And it did so for ten days, in which time the siding was repaired, the bunkers filled and the hotwell pump again available.

The art of autogenous welding is doing much to insure continuous service when interruptions seem imminent, due to equipment being cracked and broken.

Hardwood has been used to make substitute parts for broken cylinder heads, piston rings, rocker-arms, etc., and these parts have given service until the arrival of metal parts. In substituting wooden for iron or steel parts, care must, of course, be taken to make them strong enough to meet conditions or make conditions suit the strength of the parts. The thing to remember is that parts of equipment as designed and built are the best, though not necessarily the only, means of accomplishing the function of the particular apparatus.

⁂

Refrigeration and Central-Station Power

With the advent of raw-water ice which does not call for the installation of evaporators, the central station has been waking to the possibilities of a refrigerating or ice-making load. The characteristics of such plants are to their liking and help to boost their annual load factor at the period during which they carry the lightest load of the year. Starting with the month of January their load is high and continues so during the winter months. During the spring and summer there is a great falling off and the load does not begin to pick up until the month of October. From then on there is a gradual rise and in December the average central station is carrying the heaviest load of the year. Machinery must, of course, be installed to supply the heaviest draft on the station and part of it must remain inactive or at least "run light" when the demands are a minimum.

To fill up this valley in their annual load curve has been the concentrated aim of the central station, and the same may be said of the daily load which in most stations runs high in the morning and evening hours. For this very purpose there is no load better adapted than a refrigerating or ice-making plant, and especially the latter when not equipped with storage. In the average ice plant on which there is no special call for ice outside of the usual public demand, over sixty per cent. of the annual output is sold in the months of June, July, August and September. The balance is distributed over the eight months remaining. Even with storage when a uniform load is carried throughout the year there is the possibility, with large brine storage to maintain the temperature, of shutting down during the highest part of the daily peak. Refrigeration would furnish a load having ice-plant characteristics, although, perhaps, the division of the annual power requirements would be slightly different. In either case the load would be continuous and approximately uniform for twenty-four hours in the day.

It is small wonder then that central stations desire such a load and in some cases at least are offering rates much lower than they would give for the same amount of power to other consumers of energy. According to their logic, as expressed by one of their representatives at a recent convention, they can afford to dispense with the fixed charges and make a very small profit over the operating costs. It has probably occurred to them that this policy is unfair to the small light and power users, who in most cases absorb the greater part of the load. They know it is discrimination pure and simple, but the public stands for it, and besides it betters their annual load factor and the gross receipts.

It is apparent, however, that their operating cost or perhaps their profit is too high, for they have made very little headway in serving plants of over twenty-five tons capacity. There are a few exceptions, such as a plant in Brooklyn of one hundred and fifty tons capacity, which by a specially low rate has been drawn into the fold. Even in this special case it is not at all certain that an isolated plant could not do better. There are cases where power should be purchased, but these are the small plants previously cited. For a plant of any pretensions the rate must be low indeed—in fact, away below what the central station could possibly give without discriminating heavily against a large proportion of its customers—to discount the results obtained in an isolated plant properly managed and operated with fair economy.

It will be admitted that the generating cost of power in the central station is slightly lower than in the average isolated plant, but in the formation of rates the dispensers of power are under a heavy handicap caused by an expensive office and selling force, transmission losses to the service, the possibilities of using exhaust steam for heating and high overhead charges due to the enormous investment required. Then profits must be considered and in the past there has been more or less trouble in transmitting the power from a motor to the compressor shaft.

If all these items are considered and included in the rate, the central station could not possibly compete with an efficient isolated plant of sufficient capacity to produce average results. If the rates are based on operating and transmission costs only and the other consumers are forced to pay all of the fixed charges, the competition would be much closer. Even then the rate must be exceptionally low or the steam plant should rule the favorite, and if we can believe all we hear about oil engines there would be no chance at all for the central station.

⁂

The "dense smoke" nuisance in New York City again looms ominous on the horizon. The Appellate Division of the Supreme Court directs that impending cases be investigated and proceeded with. It was only last summer that the smoke ordinance was declared "unreasonable and unconstitutional" by three judges. Some day in a future remote, when the coal supply is exhausted and there is nothing to produce smoke, New Yorkers will create an excellent smoke-inspection department. In the meanwhile bring on the soft coal; let furnace design go where it will! Let judges and health officers wrangle in the ever thickening smudge. We should worry!

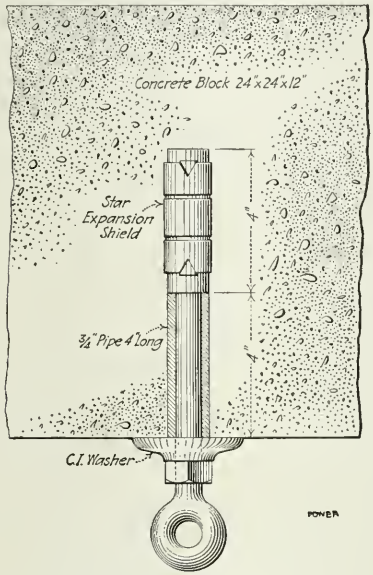
⁂

The index of POWER for the second half for 1913, Volume 38, will be ready early in January, and will be sent without charge only to those requesting it.

READERS WITH SOMETHING TO SAY

Test of Expansion-Bolt Shield

Desiring to put an I-beam trolley under the power house to take out the draft tubes on the exciter units, and as the roof of the bays was 20 in. of concrete, five years old and heavily reinforced, drilling holes for six bolts would be no little task. Besides, the wheel casings



How the Bolt Was Inserted

would prevent getting bolts at the ends of the beam, next the tubes. So I determined to test a ¾-in. Star double-expansion shield for machine bolts.

I used a block of concrete 24x24x12 in. It was five years old, not reinforced, and was made of Ideal cement, one part to six of sand and gravel. A hole was drilled into the block 8 in. and of a size to allow the shield to slip in, care being taken in having the hole round and straight. The shield was placed at the bottom of the hole, and a piece of ¾-in. pipe just long enough to come flush with the face of the concrete placed on top. A ¾-in. I-bolt, made of common mild steel stock, standard ten V-thread, with a shoulder just under the eye and a washer on this shoulder, was screwed into the shield; the washer pressed against the end of the pipe and the face of the concrete, and the bolt was forced up until the shield had expanded.

The block was placed on a scaffold, and a platform suspended to the I-bolt by means of chains. The platform was loaded with pig tin, lead, babbitt, lava rock and heavy scrap iron until the chain gave way, a link being defective. Weighing the load, we found it to be 6181 lb.

As this was five and seven-eighths times the weight of the tube to be removed, and as we intended to use six bolts and shields to carry the trolley, we deemed the test sufficient. Examination of the bolt previous to loading on the last 400 or 500 lb. before the chain gave way, showed that the bolt gave no sign of loosening. After the load was removed, the shield was taken out. It showed only a slight contorsion at the lower or threaded end.

I think power-house men will find these expansion shields very useful for putting up small trolleys, I-bolts, or mounting brackets on the wall, anchoring down motors, etc., but care must be taken not to drill holes too large, and to have them round, and if possible twice the depth of the shield; and a piece of pipe should be used between the shield and the shoulder on the bolt, unless the shield comes flush with the face of the concrete, in which case the end of the shield will rest against the shoulder.

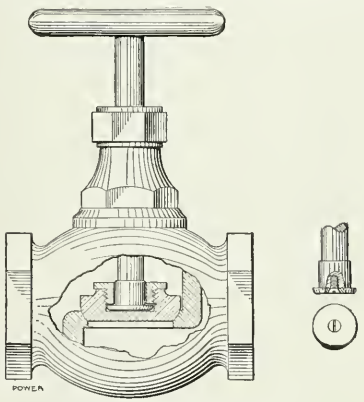
Ira F. Johnson.

Minidoka, Idaho.

Valve-Spindle Repair

A 1½-in. valve in one of the departments of our plant had been leaking badly for some time, and no report of it made. The valve was situated on the horizontal with steam on top of the brass disk.

One morning on opening the valve, steam would not flow through. After investigating I found that the brass



Valve and Details of Stem

disk had dropped off the spindle and the head of the spindle was worn down and twisted off as indicated by the arrows in Fig. 1.

Exerting too great a pressure on the handwheel to bring the disk tight on the seat to prevent it from leaking, resulted in this trouble. I found a piece of plate brass ⅛ in. thick, filed it round as possible, then drilled the hole in the center and countersunk it for a flat-headed machine screw. The spindle was then placed in the lathe and ⅛ in. taken off the end. I next drilled and

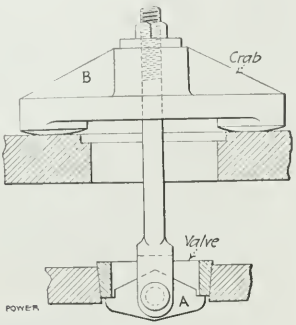
tapped a hole in the center for an $^{8}/_{32}$-thread machine screw. After putting the piece of brass plate on it was as shown in Fig. 2. The job was finished in about ten minutes.

FREDERICK L. JOHNSON.

Paterson, N. J.

Device for Removing Pump-Valve Seats

The device shown herewith is useful and saves trouble in removing valve seats from the valve plate of pumps. When it is desired to remove a seat the pull bolt is placed



PUMP-SEAT REMOVER IN PLACE

in position with the head *A*, which swivels, under the seat. The crab *B* which holds down the valve cap can be used as a bar when screwing up the nut, although any bar with a hole in the center will answer the purpose. The nut is screwed down on the pull bolt and the seat will readily come out. The head *A* can be made to fit any size seat.

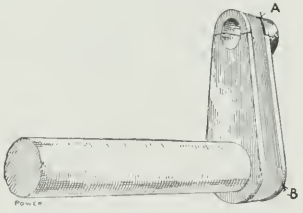
This device can also be used for removing water-cylinder sleeve by making the head *D* larger to suit.

W. WOLFGANG.

Toledo, Ohio.

Broken Crank Repaired with Wire

The valve-stem crank of a cold-brine pump broke through the crankpin bore. As shown the casting about the upper half of the crankpin fell entirely off. It broke about 11 o'clock at night, and as there was no machine shop open at that time of night, it was necessary to make



WIRE HOLDING BROKEN CRANK

a quick repair to hold the temperature in the freezer rooms.

Slots *A* and *B* were filed in the small and large ends of the crank. The pin was placed in position, the broken part placed over it and fine steel wire was then wound around the crank until the slots were filled. Over this fine wire one round of large copper wire was placed to hold the fine wire as the steel wire would break when attempting to tighten by twisting it. The pump has been operating for several days, the wire remaining in position.

G. A. ROBERTSON.

Louisville, Ky.

Firebrick Specifications

The following firebrick specifications are in use by the writer and are here given for the benefit of the profession. I trust that there may be some discussion of them, as, no doubt, all will not agree with the methods of construction. Anyone who has to be responsible for firebrick construction knows what a task it is to get good brick and have them laid up right:

FIREBRICK WORK—All firebrick shall be protected from moisture, and shall be dry when used. Each brick shall be dipped in a thin fine clay wash, rubbed and shoved into its final place, and then tapped with a wooden mallet until it actually touches the brick below it. The use of clay thick enough to lay with a trowel will not be permitted.

The walls of fire and red brick shall be carried up together. Furnace linings shall be laid four courses of headers and then one stretcher backed by a firebrick header. Furnace center walls shall be solid firebrick. Walls with 4½-in. linings or all red brick walls shall be laid with each header course on the inside of the wall lapping over a header course in the center of the wall, which in turn laps above a header course on the outside.

FIREBRICK ARCHES—If fire arches are called for by the drawings, the skewbacks shall be laid off parallel and at the same height with a straight-edge as long as the arch. The skew shall be a true surface, cut only on the ends of the brick. There shall be firebrick back to the buckstays on single settings, and entirely through the center wall on battery settings.

Batten strips for the arch centers shall not be more than 2 in. wide. Selected brick only, smooth, straight and uniform, shall be used in the arches. Brick shall be laid dry without any clay; and shall be shoved together close and tapped with a wooden mallet on the flat side only of the brick. They shall be laid in courses along the arch center, beginning at the rear end of the arch, not in rings, and with every joint broken, and with a bond equal to one-half of the brick. The first course shall start at the skewback on each side with a standard brick 4½ in. wide; the second at each side with a "flat back" 6½ in. wide; the third course 4½ in. and so on. To finish the courses at the front wall, a "flat back," cut to suit when necessary, shall be used. Each course shall be tried in place dry, and shall be checked with a straight-edge to insure all the brick of one course being the same thickness. Bricks not of even thickness must be cut and rubbed. A course of wedges shall be used only when necessary to keep the bottoms of the straight brick in even contact with the arch center. If the use of wedges does in every case bring a straight brick to an even bottom the straight brick should lean away from the center of the furnace rather than toward it. A trial ring shall be laid, when about two-thirds of the arch has been completed, to determine if the keying course will fit. If cutting is

necessary to fit the keying course, the key brick shall not be cut, but instead, the two adjacent courses on the side of the brick away from the key. The keying course shall be a true fit from top to bottom, of such thickness that when driven it shall not be below the surface of the arch, and shall preferably stand about ¼ in. above it. The keys should drive from 1 to 2½ in.

After fitting, the keys shall be loosely replaced, and then with a piece of wood, at least 2x4 in., extending the full length of the keying course, shall be driven uniformly to place with a heavy hammer, used along the entire length of the timber. After driving, the keys shall not show any crushing. When keyed up the top of the arch shall be thoroughly washed with a thin fireclay wash.

Centers shall be built so that they can be dropped down free of the arch after it is keyed, and removed from the setting without being burned out.

FREDERICK L. RAY.

Louisville, Ky.

Cause of Flywheel Explosions

Sometime ago I viewed the wreckage of a burst flywheel of a Corliss engine. The engine, doubtless, ran away, but as to the cause there was a difference of opinion.

Evidently the start of the wreck was in the bursting of a driven pulley that was either too light for the work or was cracked, when a sudden load was thrown on it. The chief engineer claimed a piece of this pulley disabled the governor, which allowed the engine to run away, thus bursting the flywheel, but the only damage done to the governor was the breaking of both the reach-rods running to the cam collars.

The chief engineer's opinion seemed to be correct, until hearing the story of the engineer immediately in charge of the engine in question.

The running engineer said he was about 50 ft. from the engine when he heard a loud report and saw the driven pulley broken, and the drive belt flopping. He ran to the engine, which by this time was going so fast it seemed to him impossible for the valves to pick up, and was in the act of closing the throttle when the governor rods, previously mentioned, flew up and struck him in the face. The bursting of the wheel following in quick succession, after which he knew nothing until restored to consciousness some time afterward.

The governor was all right when he got to the engine, and as the rods were the only parts of the governor damaged, it seems the broken pulley did not interfere with it at all. This placed the adjustments of the governor in a bad light, which subsequent inspection verified.

The knockoff cams were sheared off and the stop-collar, or collar that limits the upward travel of the governor sleeve, as well as the sleeve also, were up to the top connections of the governor arms. The piston of the gag-pot was lifted out of the cylinder. The breaking of the governor rods was probably caused by the tail of the hooks dropping behind the square end of the cams when the latter was thrown too far around, due to the slipping of the stop collar.

That being the case, there would evidently be a mark across the tail end of the hook caused by the sharp edge of the steel cam, the hooks being of brass. Inspection revealed such marks on each hook, and on laying the cam in its proper place and bringing the hook up against it, it was found that the edge of the cam fitted into the mark exactly.

Therefore it seems that the cause of the engine running away was the adjustment of this collar. It was either set too low, or if set in the correct position was not sufficiently tightened to prevent slipping. In either case it does not seem to have been tight enough to resist the upward pull of the governor sleeve.

Suppose it is set too low and the engine is suddenly relieved of all its load. The engines will speed up, the governor rising to the collar, the steam valves still opening too wide, the engine increases in speed, placing more stress against this collar. Just before the speed becomes too great for the wheel to withstand, this collar slips, the governor moves up far enough to roll the knockoff cams past the tail of the hooks. The latter, on their return, catch the square end of the cams, shearing them off, breaking the governor rods at the same time and augmenting the upward movement of the governor sleeve, thus pushing the sleeve and collar up to where they were found and the piston of the gag-pot clear of the cylinder.

Suppose this collar is set in the correct position, but not properly secured. It might have been possible for the engine to have speeded up sufficiently to have thrown the governor sleeve against this collar about the time the engineer arrived, and slipped it far enough to allow the hooks to catch the cams as stated. In this condition the engine would probably require only a stroke or two with steam following the length of the cylinder, to reach the bursting point of the flywheel.

It was suggested by a few that the cams could not be thrown clear under the hooks as stated, but on testing it on a duplicate engine of the one wrecked it was found that it could be accomplished.

It seems to many that the wrong adjustment of this collar was the cause of the wreck. Of course, the real starting of it was through the breaking of the driven pulley.

It is well to test the adjustment of this collar from time to time for it may be needed only once in the life of the engine, but it will be fraught with constant danger if allowed to become other than correctly adjusted. Changing the reach-rods of a governor from time to time will necessitate the readjustment of this collar. A knockoff cam should be made longer or tapered at both ends. Either will prevent the hook catching when the cams are rolled too far under.

JOSEPH STEWART.

Hamilton, Ohio.

Priming a Condenser-Circulating Pump

In a certain plant with which the writer is acquainted, much difficulty was experienced with priming the circulating pumps of a condenser. These pumps were arranged to draw water from two sources; one feed was from a head race and the water was supplied to the pumps under a head of 10 ft. At times this supply source could not be depended on, due to the clogging of the trash racks over the intake pipe, with leaves and ice. At times also during repairs to the race, this supply was cut off entirely. When this happened the other connection, drawing water from the river, under a suction lift of about 5 or 6 ft., was used. Great difficulty was experienced in getting the pump to lift the water, because of

lack of means for priming. It was thought that sufficient water could always be obtained from the race for this purpose, which, however, proved untrue.

A quick means for accomplishing this priming was necessary as the condenser depended upon these pumps and the loss of vacuum attending would cause a serious shutdown. The following plan was suggested to my mind by the proximity of the dry-vacuum pumps which were a part of the condenser equipment. A three-quarter hole was drilled and tapped in the intake pipe of the air pump at its highest point, and in the casing of the centrifugal pump. These two holes were connected by means of a pipe, with a valve inserted in it, near the circulating pump. The air in the suction line could then be exhausted by means of the vacuum pump and the water would rise in the pipe, due to the atmospheric pressure, allowing the pump to readily pick up its water. The valve would then be closed, preventing any water from being drawn over into the air pump.

This plan was not put into effect, to the writer's knowledge, only suggested by him as a way out of a difficulty.

James M. Purcell.

Richmond, Va.

Lubricating Links of Duplex Pumps

The links as made by the manufacturer were as shown at the left of the illustration. Difficulty was experienced in lubricating these links and pins to prevent them wear-

Grease Cup to Lubricate Pump Links

ing rapidly. New links and pins were finally obtained, the pins being made as shown at the right. By using grease cups the lubrication is better and the pins last much longer than formerly.

A. R. Kummerer.

Hazleton, Penn.

Your Son's Vocation

The editorial, "Your Son's Vocation," in the Oct. 28 issue, brings up a subject uppermost in the minds of men who have the welfare of their children at heart.

As a general rule, most boys show more interest in things mechanical than in any others. This before they are old enough to think seriously about the vocation for which they are best fitted. By the time the boy has gone through common school, and in many cases before that, it is usually possible to determine in which direction his ambition lies and in what line of work he is most likely to succeed. If his bent is mechanical and he is sure that nothing but an engineer's life will suit him, by no means should he be denied an opportunity to make good. But he should be given at least a technical high-school education and if possible more than that. He should not be handicapped by having to start to work with no theoretical training. It is true that there are men holding responsible and well paid positions in the engineering field who, in their youth, did not have anything more than the "three R's," but their rise has been in spite of their lack of early training and not because of it. It is possible to obtain, by home study, the equivalent of a college course in engineering, but it is mighty hard work and every man who tries it will have to admit that the proper place to acquire such an education is in the classroom, and the proper time is before one has to go to work to earn his own bread and butter.

Whether or not it is wise to keep a line of descent in one line of work is a question that the writer believes can be left to nature. If a youth shows an inclination to follow any one line of employment, let him proceed. Nature fitted him for it and it would not be right to deny him the right to profit by his natural ability for his chosen work.

A. T. Walker.

Washington, D. C.

Maltreatment of Apparatus

As an example of the maltreatment of apparatus by careless employees, I would like to cite an example of a turbine-driven feed pump, which had been returned to the concern where I am employed as testing engineer, for failure to attain rated conditions after two years of perfect service.

The unit was set up preparatory to testing and had been running about 10 min., when it suddenly slowed down. Examination showed that the pump bearings were running hot, so we shut down and dissembled the pump. In the forward bearing of the pump we found that the oil-ring had been substituted for by a piece of twine, which was useless for its purpose.

The adjusting screw in the thrust bearing had been screwed up so far that the impellers were thrown out of line, and the shaft collars had by their excessive pressure against the thrust block, broken off several of the rings in the split thrust bush. Furthermore, we discovered a couple of nuts in the impellers. How they got there I cannot imagine, and their effect upon the capacity of the pump I will not attempt to describe.

Is it any wonder that the outfit failed to come up to its guaranteed conditions? Subsequent remedying of the above defects proved that the outfit was fully capable of attaining its designed conditions.

This is only one case out of many of the attempts on the parts of plant owners to economize in the wrong direction by the use of cheap and unskilled labor, and as usual the result is always the same. The above outfit had been shipped from the Pacific Coast to the East, and this would have been unnecessary if ordinary judgment had been used on the parts of those in charge.

Henry W. Wetjen.

Newburgh, N. Y.

Painted Valve Stems Indicate Valve Positions

I find it very troublesome to climb up ladders and over brick walls to find out if certain valves are open or closed. I closed the valves and then painted the stems down to the packing gland. Now I can tell whether a certain valve is open or closed by merely glancing at it.

Cylinder oil and melted paraffin make a fine remedy for burns from live steam.

Stanley Radcliffe.

Laurel, Md.

INQUIRIES OF GENERAL INTEREST

Pump Capacity—Will air chambers installed in both the ction to and discharge from a pump increase its capacity?

J. W. D.

Yes; they will reduce pump-piston slippage and thereby rease the capacity of a pump.

Resistance of Mercury Column—What is the resistance in ns of a round column of mercury 70 in. high, 0.05 in. in meter?

C. W.

1.3226381 ohms.

Compensator—What is a compensator?

V. A. N.

"Compensator" is the term applied to an auto-transformer starting an electric motor. A description of one is given the electrical department of the Dec. 2 issue of "Power," der the subject of "Induction Motors."

Relative Current Consumption—Will a 50-hp. induction tor pulling a 30-hp. load consume more current than a hp. motor carrying the same load?

E. M.

Yes, because an induction motor has a lower power factor en running underloaded.

Safety Valve Sizes—For a given size boiler why should a er safety valve be required to have a larger area than a ing-loaded valve?

J. W. D.

Pop safety valves of ordinary good construction are mpter by reason of having less friction of moving parts l are made to lift higher and hence may be smaller than er safety valves.

Refrigeration Loss—What will be the loss in horsepower-urs in a brine tank containing 15,000 gal. of a 20 per cent. ution of brine, for a 1-deg. F. rise in temperature?

A. A. R.

The brine will have a specific gravity of 1.18 at 62 deg. F. e heat required to raise or lower 1 lb. of such a solution eg. would be 0.834 B.t.u. As 1 gal. would weigh

$$8\tfrac{1}{3} \times 1.18 = 9.833 \text{ lb.},$$

n 15,000 gal. would weigh

$$15{,}000 \times 9.833 = 147{,}495 \text{ lb.},$$

uiring

$$147{,}495 \times 0.834 = 123{,}010.83 \text{ B.t.u.}$$

raising it 1 deg. F. There being 2546 B.t.u. per horse-ver per hour then warming or cooling of this quantity of ter 1 deg. F. per hour would be at the rate of

$$123{,}010.83 \div 2546 = 48.31 \text{ net hp.}$$

Modified Furnace Design—Would it be practicable to install eavy cast-steel hollow arch in a Dutch oven and force the ter from the heater at about 212 deg. through this arch to boiler to increase the life of the arches at present so fre-ntly destroyed by the intense heat?

W. C. C.

The advantage of a Dutch-oven furnace arises from the t that the roof and furnace lining are at high temperature do not retard complete combustion like the colder heat-surface of a boiler. To form the roof of water arches uld have the same detrimental effect as to extend the heat-surface of the boiler over the fire, i.e., there would be advantage over an ordinary boiler setting with the boiler the same distance above the fire. Such a water-arch cov-ng would be not only detrimental to the efficiency of com-tion, but also would be in danger of burning out or explod-from the formation of mud or scale deposits.

Clearance—How is the clearance space of an engine found; o the striking clearance?

M. W. C.

e volume of clearance space in each end of an engine nder is determined by placing the piston at the end of the ke and noting how much water is required to fill the rance spaces from the piston back to the steam valve. If water is measured by weight instead of volume the equivalent volume can be found by multiplying the weight of water in pounds by 27.77; the quotient will be the number of cubic inches of clearance space. To find the percent. of clearance, first find the displacement volume of the piston by multiplying its area in square inches by its stroke in inches and divide the clearance volume by the displacement volume. To find the striking clearance of the piston, place the engine on dead center; then make a mark on the crosshead and guides, one registering with the other; detach the connecting rod and see how much farther the crosshead can be moved before the piston touches the head of the cylinder.

Freezing Air-Drill Exhaust—What makes the exhaust from an air drill freeze and how can it be prevented?

J. R. T.

The exhaust freezes because when the air is first taken in by the compressor it contains moisture. When the air is compressed its temperature rises both because the heat contained is concentrated into a smaller space and because the work of compression is stored up in the air. When compressed to a temperature above the temperature of the atmosphere, it cools down, losing some of its heat. Consequently, when expanded down again, its temperature falls and any moisture contained in the air freezes and may clog the drill, or the air itself, being cooler than the atmosphere, may freeze the moisture of the atmosphere into which it is exhausted. Freezing up of rock drills can be prevented by taking in dry air to the compressor, or by using a reheater which usually consists of a "sugar loaf" type of stove in which the air is reheated by being passed through a pipe coil surrounding the fire pot of the stove. The reheater should, of course, be placed near the drills.

Peculiar Gage Action—In the morning two "gages" of water are found in the glass. After a few minutes the water has gone up in the glass, although no water is being fed. When the gage cocks are opened they blow dry steam. What is probably the trouble?

H. E.

A full water gage may be shown at any time when the boiler is under a few pounds of steam pressure and the upper gage-glass connection is closed deliberately or accidentally stopped. In this case the upper connection was probably closed, and the pressure had gone down in the boiler during the night so that there was not sufficient acting in the lower end of the glass gage to hold the water in the glass higher than the level at which it was found; there being a partial vacuum in the upper end of the glass gage, the water stood higher than the level of water in the boiler. After getting up a little steam pressure the pressure of steam on the water in the boiler forced the water to the top of the glass gage, although during the whole time the actual level of water in the boiler was lower than shown by the glass gage.

Boiler-Evaporation Problem—A boiler generates steam at 105-lb. gage pressure. The feed-water temperature is 203 deg. F.; the efficiency of the furnace and boiler is 70 per cent., and the coal contains 14,000 B.t.u. per lb. How many pounds of water will the boiler evaporate per pound of coal?

J. P. L.

Steam at 105-lb. gage pressure would be at

$$105 + 14.7 = 119.7 \text{ lb. absolute pressure,}$$

containing practically the same heat as at 120 lb. absolute. The total heat above 32 deg. F., as obtained from Marks and Davis' steam tables, is 1189.6 B.t.u. per lb. (weight). The initial feed-water temperature being 203 deg. F., each pound already contains

$$203 - 32 = 171 \text{ B.t.u.}$$

Each pound of water made into steam, therefore, requires

$$1189.6 - 171 = 1018.6 \text{ B.t.u.}$$

A pound of coal containing 14,000 B.t.u. with a 70 per cent. efficiency of furnace and boiler would impart

$$0.70 \times 14{,}000 = 9800 \text{ B.t.u.}$$

to the water. Therefore, each pound of coal could evaporate

$$\frac{9800}{1018.6} = 9.62 \text{ lb. of water}$$

into dry, saturated steam at 105 lb. gage pressure.

ENGINEERS' STUDY COURSE

Trigonometry—IV

LAST LESSON'S ANSWERS

11. The tangent and cotangent of the same angle being reciprocals (last rule in the last lesson) if $tan\ A = 3$, $cot\ A = \frac{1}{3}$.

12. Given $tan\ A = \frac{4}{5}$. The tangent and cotangent being reciprocals $cot\ A = \frac{5}{4}$. Substituting in equation 7 (last lesson),

$$sec^2\ A = 1 + (\tfrac{4}{5})^2 = 1 + \tfrac{16}{25} = \tfrac{41}{25}$$

and

$$sec\ A = \sqrt{\tfrac{41}{25}} = \frac{\sqrt{41}}{5}$$

The secant and cosine being reciprocals

$$cos\ A = \frac{5}{\sqrt{41}}$$

Substituting in equation 1

$$sin^2\ A + \left(\frac{5}{\sqrt{41}}\right)^2 = 1$$

$$sin^2\ A = 1 - \left(\frac{5}{\sqrt{41}}\right)^2 = 1 - \tfrac{25}{41} = \tfrac{16}{41}$$

and

$$sin\ A = \sqrt{\tfrac{16}{41}} = \frac{4}{\sqrt{41}}$$

The cosecant and sine being reciprocals

$$csc\ A = \frac{\sqrt{41}}{4}$$

Substituting in equation 9

$$vers\ A = 1 - \frac{5}{\sqrt{41}}$$

Substituting in equation 10

$$covers\ A = 1 - \frac{4}{\sqrt{41}}$$

13. Draw an angle of 30 deg. as BAC, Fig. 5, with AB equal to 1 (any unit), and AC a horizontal line. Below this horizontal line draw another angle of 30 deg., CAD. These angles being equal their cosines are equal and in fact coincide as represented by the line AE. Therefore, the sines BE and ED of the two 30-deg. angles will be continuations of one another, and equal because they are the sines of equal angles. Being equal, the angles of which they are cosines, ABE and ADE, are equal, as is also known from the fact that they are both complements of 30-deg. angles and hence 60 deg. (90 — 30 = 60). There is now constructed an *equiangular triangle* (one in which all of the angles are equal) $ABDA$. Now, if a line be drawn from B to the opposite side AD and at right angles to it, as BF (this is called dropping a perpendicular to AD) it will divide the triangle $ABDA$ into two right triangles $ABFA$ and $BDFB$, and angles BAF and BDF being angles of 60 deg., angles ABF and DBF be angles of 30 deg., showing that the perpendicular *bisected* (divided in two equal parts) the angle ABD, already shown to be one of 60 deg. These angles being equal, their sines, AF and FD are equal, hence bisect the line AD, which by construction was equal to 1. Hence it is proved that $sin\ 30\ deg. = \frac{1}{2}$. Incidentally, BE and ED, each being a sine of 30 deg. and therefore equal to $\frac{1}{2}$, it proves that the chord of an angle (or arc) of 60 deg. is equal to 1, for such is BD. Another truth established is that the sides of an equiangular triangle are equal, and therefore such a triangle is also known as an *equilateral triangle*.

14. The sine of 30 deg. being $\frac{1}{2}$, by equation 1

$$cos\ 30° = \sqrt{1 - (\tfrac{1}{2})^2} = \sqrt{1 - \tfrac{1}{4}} = \sqrt{\tfrac{3}{4}} = \frac{\sqrt{3}}{2}$$

and, being the reciprocal of the cosine,

$$sec\ 30° = \frac{2}{\sqrt{3}}$$

By equation 2

$$tan\ 30° = \frac{\frac{1}{2}}{\frac{\sqrt{3}}{2}} = \tfrac{1}{2} \times \frac{2}{\sqrt{3}} = \frac{1}{\sqrt{3}}$$

and, being the reciprocal of the tangent,

$$cot\ 30° = \sqrt{3}$$

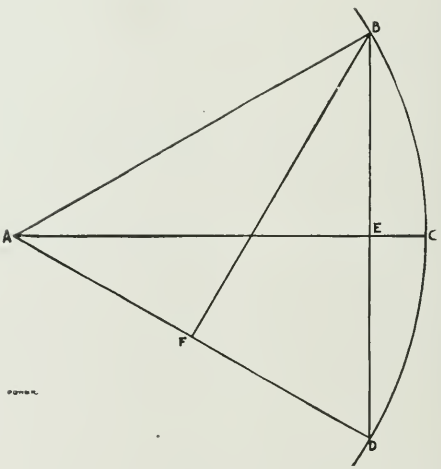


FIG. 5

Being the reciprocal of the sine

$$csc\ 30° = 2$$

By equation 9

$$vers\ 30° = 1 - \frac{\sqrt{3}}{2}$$

By equation 10

$$covers\ 30° = 1 - \tfrac{1}{2} = \tfrac{1}{2}$$

15. The sine of an angle being the cosine of its complement and 45 deg. being the complement of 45 deg., the

gine and cosine of 45 deg. are equal. In equation 1, substituting cos^2 for sin^2.

$$2\ sin^2\ 45^\circ = 1$$

or

$$sin^2\ 45^\circ = \tfrac{1}{2}$$

or

$$sin\ 45^\circ = \sqrt{\tfrac{1}{2}} = \frac{1}{\sqrt{2}} = \text{also } cos\ 45^\circ$$

Being the reciprocal of the cosine,

$$sec\ 45^\circ = \sqrt{2}$$

Being the reciprocal of the sine,

$$csc\ 45^\circ = \sqrt{2}$$

By equation 2

$$tan\ 45^\circ = \frac{\frac{1}{\sqrt{2}}}{\frac{1}{\sqrt{2}}} = 1$$

Being the reciprocal of the tangent,

$$cot\ 45^\circ = 1$$

By equation 9

$$vers\ 45^\circ = 1 - \frac{1}{\sqrt{2}}$$

By equation 10

$$covers\ 45^\circ = 1 - \frac{1}{\sqrt{2}}$$

Functions of the Sum and Difference of Angles

Designating any two angles by A and B, the functions of their sums and differences may be deduced. Taking, as the first proposition to prove that *the sine of the sum of two angles is equal to the sine of the first times the cosine of the second, plus the cosine of the first times the sine of the second.*

Referring to Fig. 6, let angles CAB and BAD represent any two angles A and B, respectively laid off with a measuring circle CBD of unit radius. BE and DF represent then the sines of the two angles separately and DI the sine of the sum of the two angles. By the proportionality of the sides of similar triangles (Lesson I, Nov. 25, 1913)

$$\frac{FG}{BE} = \frac{AF}{AB}$$

$$FG = \frac{BE \times AF}{AB} = \frac{sin\ A\ cos\ B}{1}$$

Also triangle $DFHD$ is similar to triangle $ABEA$ (because each side of the one is perpendicular to the corresponding side of the other) and

$$\frac{DH}{AE} = \frac{DF}{AB}$$

$$DH = \frac{AE \times DF}{AB} = \frac{cos\ A\ sin\ B}{1}$$

Since

$$HI = FG$$

$$DI = FG + DH$$

or

$$sin\ (A + B) = sin\ A\ cos\ B + cos\ A\ sin\ B \qquad (11)$$

To show that *the sine of the difference of two angles is equal to the sine of the first times the cosine of the second, minus the cosine of the first times the sine of the second.*

Let the angle A now be represented by the angle CAD, Fig. 6, and the angle B by CAB. Again, by similar triangles.

$$\frac{DH}{AE} = \frac{DF}{AB}$$

$$DH = \frac{AE \times DF}{AB} = \frac{cos\ B\ sin\ (A - B)}{1}$$

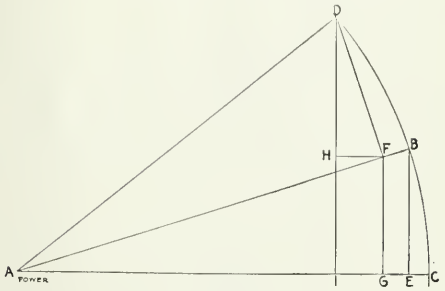


Fig. 6

and

$$\frac{FG}{BE} = \frac{AG}{AE}$$

$$FG = \frac{BE \times AG}{AE} = \frac{sin\ B \times AG}{cos\ B}$$

but

$$AG = AI + IG$$

or, since

$$IG = HF$$

$$AG = AI + HF = cos\ A + HF$$

Again, by similar triangles

$$\frac{HF}{BE} = \frac{DF}{AB}$$

$$HF = \frac{BE \times DF}{AB} = \frac{sin\ B\ sin\ (A - B)}{1}$$

Substituting in the equation for AG

$$AG = cos\ A + sin\ B\ sin\ (A - B)$$

and substituting this value for AG in the equation for FG

$$FG = \frac{sin\ B\ [cos\ A + sin\ B\ sin\ (A - B)]}{cos\ B}$$

$$= \frac{sin\ B\ cos\ A + sin^2\ B\ sin\ (A - B)}{cos\ B}$$

Now

$$DH = DI - HI$$

or, since

$$HI = FG$$

$$DH = DI - FG = sin\ A - FG$$

Substituting the values already found for DH and FG

$$cos\ B\ sin\ (A - B) = sin\ A - \frac{sin\ B\ cos\ A + sin^2\ B\ sin\ (A - B)}{cos\ B}$$

Multiplying both sides of the equation by $cos\ B$

$$cos^2\ B\ sin\ (A - B) = sin\ A\ cos\ B - sin\ B\ cos\ A - sin^2\ B\ sin\ (A - B)$$

Transferring the last term to the other side of the equation to collect like terms

$$cos^2\ B\ sin\ (A - B) + sin^2\ B\ sin\ (A - B) = sin\ A\ cos\ B - sin\ B\ cos\ A$$

and simplifying

$$[cos^2\ B + sin^2\ B]\ sin\ (A - B) = sin\ A\ cos\ B - cos\ A\ sin\ B$$

since

$$\cos^2 B + \sin^2 B = 1$$

$$\sin (A - B) = \sin A \cos B - \cos A \sin B \qquad (12)$$

Study Questions

16. Given $\sin 30° = \frac{1}{2}$, and $\sin 45° = \sqrt{\frac{1}{2}}$, find $\sin 75°$.

17. Given the same, find $\sin 15°$.

18. Deduce an expression for the sine of the sum of two angles plus the sine of their difference.

19. Show that *the cosine of the sum of two angles is equal to the product of their cosines minus the product of their sines.*

20. Show that *the cosine of the difference of two angles is equal to the product of their cosines plus the product of their sines.*

Blonck Boiler-Efficiency Recording Meter

The accompanying illustrations show the newly developed recording type of Blonck boiler-efficiency meter, manufactured by W. A. Blonck & Co., Fisher Bldg., Chicago, Ill. As in the indicating type, the recorder shows the draft resistance of the fuel bed and the drop in draft between furnace and damper. The two records are made on the same chart and for clearness one is registered in red, and the other in blue ink.

The recorder is to be used in conjunction with the indicating meter, the former located where the chief engineer or superintendent may have ready access to it and the latter on the boiler front for the guidance of the fireman.

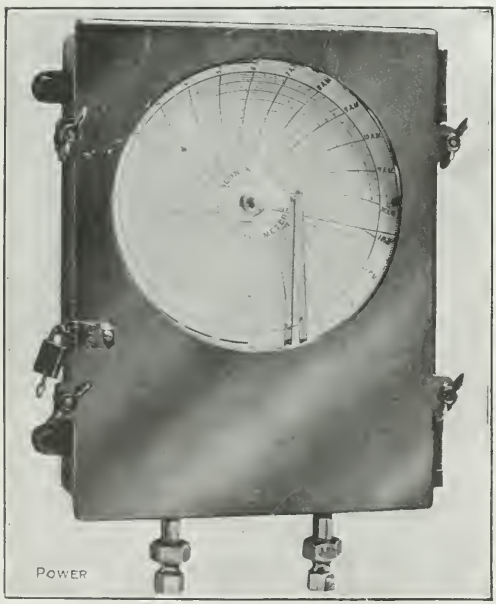


Fig. 1. Blonck Boiler-Efficiency Recording Meter

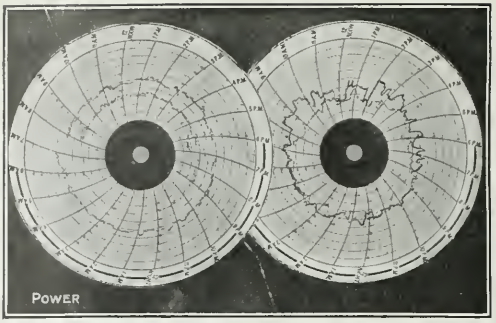


Fig. 2. Specimen Charts Showing Poor and Good Operation

The charts in Fig. 2 show conditions before and after the Blonck indicating meter was applied and its use explained to the fireman. The boiler affected is a 500-hp. horizontal water-tube unit fitted with a traveling chain grate. The total available draft is somewhat more than 0.8 in., water gage, and investigation showed that for highest efficiency under normal conditions of load the draft through the fuel bed should be 0.3 in. and that through the boiler, 0.5 in.

On the upper chart, taken before the fireman was instructed, the draft distribution is irregular, extreme variations occurring within short periods. The draft through the fuel bed varied from the maximum of 0.5 in. near 2 a.m. to the minimum of 0.18 in. at 2 p.m. With the damper position unchanged a decrease in the draft through the fuel bed results in admission of excess air and resultant waste. Excess air means a greater volume of gases flowing through the boiler per unit of time and, hence, an increase in the draft between furnace and damper. These facts account for the behavior of the two record lines of the charts at the points where they are converging or diverging.

During the periods (exceedingly brief on the upper chart) when the lines run practically parallel, as at 9 a.m., the conditions remain uniform. When the record shows a decrease in both the draft through the fuel bed and that through boiler, the indications are a decrease in the rate of combustion (hence, decrease in steam output also) and no change in efficiency. When increase in both furnace and boiler draft is shown, the indications are increase in rate of steaming and no change in efficiency.

Other things remaining the same, the rate of steaming or boiler capacity developed and the efficiency of the boiler depends solely upon the available draft and the distribution of that draft. This being true, it is possible to study a given set of boiler conditions so thoroughly that, with the Blonck meter, practically all changes that occur to affect the two factors of capacity and efficiency, can be instantly detected. Indeed, so absolute is the relation between draft and capacity and efficiency, that even fallen baffles and soot or slag accumulations on the tubes may be discovered through their effect on draft distribution.

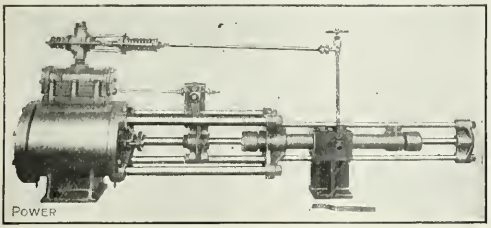
The total horsepower of turbines now installed or on order with the Parsons Marine Steam Turbine Co. exceeds 10,000,000, of which 2,100,000 hp. has been ordered within the past year.

Steam-Driven Hydraulic Pump

The illustration shows one of a new line of steam-driven hydraulic pumps built by the Hydraulic Press Manufacturing Co., Mount Gilead, Ohio. Based on the steam-end dimension the line covers 12 sizes, and on the water-end dimension 71 sizes. This pump is of the single-cylinder, double-acting type.

The stroke is longer than has been provided by previous designs. The number of strokes is proportionately less. This reduces the slippage at the water valves as well as the wear on all moving parts. Another advantage is that a given steam piston can be used with various sizes of water plungers to give capacities desired, or the steam pressure may be reduced to obtain a given water pressure.

The design of valves and gears prohibits the short stroking of the pump. The steam valve-gear permits adjustment to be made while the pump is in motion. The cushioning of moving parts is positive and does not require adjustment. Steel forgings are used for all water



STEAM-DRIVEN HYDRAULIC PUMP

ends for pressures above 2000 lb. The water valves are large in area. All the seats are removable and all parts are accessible.

Mounted on the steam chest is shown the pressure and speed governor which regulates the speed and pressure of the steam-driven hydraulic pump. It can be used as a simple automatic control for any make of hydraulic steam pumps. It is provided with an adjustment which can be set to govern any speed and pressure desired. It cuts off the steam supply to the pump when the predetermined maximum pressure is reached, and regulates the speed of the pump to any number of strokes for which it may be adjusted, thus preventing the pump from racing, should the pressure be released suddenly.

⁂

A 250-Mile Pipe Line is being built for H. M. Byllesby & Co., of Chicago, from the West Virginia Gas Fields to Louisville, Ky. Some 76 miles of difficult construction through the mountains has already been completed.

⁂

Coal Bulletin—The Bureau of Mines bulletin No. 22 treats of an analysis of 5000 samples of coal that have been collected by experienced government agents from 1500 mines in the United States. The bulletin is in two sections, one giving the methods of procedure followed in taking samples and in testing them and the other showing the location of the coal mines where the samples were obtained and data on the physical conditions existing at the different mines, their capacity and their methods of preparing coal for the market. Such a book should be valuable to power-station managers who could, by referring to it, make analysis of coal by the best approved method and find out much valuable information on the condition of the mines from which his coal is taken and obtain a rough figure of the heating value of the coal by knowing the location of the mine. Copies of the bulletin may be obtained by addressing Bureau of Mines, Washington, D. C.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

"Safety first!" is bully, but it's a big financial undertaking for the railroads alone. For two moves in this direction it will require nearly a billion of dollars—$700,000,000 to replace wooden cars with steel; $300,000,000 for suitable signal services. This does not include better track, bridges, stations, grading, etc.

⁂

"Are factory whistles necessary?" is being discussed by a contemporary. Factory whistles have very little to blow about these days what with the "Big Boob" and the "Insomnia" clocks, and other contraptions that rob us of our early-morning rest. The time-clock is the merry little chirper for starting-time with the majority of us, and most any simp knows when to stop.

⁂

The first elevator installed in a New York office building was in the old Equitable, in 1870. On this same site today there is being erected a building that will house more elevators than any other structure in the world. Going up? You bet!

⁂

The Emproar Willyum finds time during his many activities to inveigh against the smooth upper lip. Willyum gets in dutch with us when he says "a real man wears a mustache." While we let the cook strain our soup, we are perfecting a patent muffler for those diners who do their own straining. And this silencer will be all to the consommé!

⁂

Chimnies are running a close second with the "largest" turbine, steamship and engine. We will soon have a 400-ft. steel stack out in Jerome, Ariz., the steel for which is being "fabricated," says a contemporary. And still they say engineers are poor writers!

⁂

"Bangor Whiskey Explodes."—Headline.

The Bangor brand must be some lively stuff. Around here our kind sort of leans up against the bottle, has no energy, no kick—just completely disheartened and spiritless. Bangor might be a good place to spend our next vacation if—

⁂

Another one of those lively "get-acquainted" towns is Racine, Wis., evidence of which is shown in the pictorial supplement of the "Journal-News." Pretty nigh all the home-folks got in the picture, including George H. Wallace, "engineer and writer," who sits plumb up against the clergy, the law, medicine, a couple of cheery-looking undertakers, and a dentist who seems to have had a strong pull with Geordie.

⁂

"Set domestic science to music."—Daily Paper.

Not for ours! Once, in the long ago, our blushing bride meant well when she started to sing as she started to cook. And she never afterward learned to love "Where Is My Wandering Boy Tonight?" You have to be good at both to win out.

⁂

"Agricultural production, marketing and coöperative effort are matters of major importance, and any help you can give the farmer will benefit your readers," the New York City Club tells us. We wish we could do just this little thing for Si, Hi and Ezry, but— "Power" is an operating engineers' paper. If we ever do take on an extra department, our first sympathies are for a "Hints to Mothers" or "Balm for Wounded Hearts" column.

⁂

This is a pretty kettle of fish! Harry Schmelt went swimming among the household effects of one Jacob Herring, of New York City. Schrimp was the cop who threw the hook into Schmelt and landed him in the "aquarium." Evidently Schmelt mistook Herring for an oyster as he opened up on a pearl necklace belonging to Mrs. Herring.

⁂

Hooray for the "Auburn (N. Y.) Citizen." Some civic pride and boosting of "the home of the Diesel engine"—that's Auburn! This live-wire paper had a corking good story on the new McIntosh & Seymour Corporation, and yards of it. Go it, "Auburn Citizen," we like your enterprise.

Mechanical Engineers' Convention

In point of attendance the thirty-fourth annual meeting of the American Society of Mechanical Engineers, held in New York City, Dec. 2 to 5 inclusive, was the largest in the history of the society. Almost thirteen hundred registered, there being 794 members and 504 guests present. Not only did the large attendance speak well for the efforts of the Meeting Committee in providing an attractive program, but the interest manifested in the papers presented, as shown by the active participation in the discussion and the numbers which took part in the various excursions, indicated that the technical and social entertainment provided was highly appreciated.

OPENING SESSION

The meeting was formally opened Tuesday evening in the auditorium of the Engineering Societies building with the presentation of the address of the retiring president, Dr. W. F. M. Goss. His subject was "Technical Education a Factor in the Development of Professional Ideals." As an educator of prominence himself the speaker was well qualified to draw conclusions from the history of technical education

JAMES HARTNESS, NEWLY ELECTED PRESIDENT OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

in the last forty years of its development as to its trend at the present and the lines along which it will probably progress. He regards the pioneer days as substantially over, that the industries and professions generally now have confidence in the technical graduate and that more and more will be expected of him, requiring that henceforth those who would reach the highest positions should follow post-graduate work and give considerable attention to research.

Following the address the report of the tellers of election was given and the following officers for the ensuing year were declared elected: President, James Hartness, Springfield, Vt.; vice-presidents, Henry L. Gantt, New York; E. E. Keller, Detroit, Mich.; H. G. Reist, Schenectady, N. Y.; managers, A. M. Greene, Jr., Troy, N. Y., John Hunter, St. Louis, Mo.; Elliott H. Whitlock, Cleveland Ohio; treasurer [illegible] H. Wiley, New York.

There followed the reception to the retiring and newly elected presidents in the society's rooms with an informal dance and collation.

THE NEW PRESIDENT

James Hartness was born in Schenectady, N. Y., in 1861. After completing his education, he worked as foreman in several different manufacturing plants in Connecticut, and, in 1888, became connected with the Jones & Lamson Machine Co., Springfield, Vt. He served successively as superintendent, manager and president, which position he now holds. Mr. Hartness is an inventor and author of note in the engineering world, having brought out numerous labor-saving machines, among them being the Flat Turret lathe and the Lo-Swing lathe.

In 1910 he invented a turret equatorial telescope, which permits the astronomer to make observations without being exposed to the cold in extremely cold weather. This accomplishment has been generally considered a marked advance in the science of optics, and that it will have an important bearing on the work of astronomers.

Mr. Hartness is a member of numerous engineering and scientific societies, both American and foreign, and is the author of "Machine Building for Profit" and "The Human Factor in Works Management."

WEDNESDAY SESSIONS

In the auditorium Wednesday morning was held the annual business meeting at which were presented the reports of the Council and standing committees. Among the latter was the report of the subcommittee on fire protection which recommended a national standard for hose couplings to do away with the present difficulty when adjacent towns attempt to help one another during serious conflagrations and are hampered by the variance in threaded connections now in use.

The Committee on an International Standard for Pipe Threads has sent to the Paris representative, L. B. Benet, instructions for presentation to the International Commission on Pipe Threads. At the request of a number of members and manufacturers, a committee was appointed and presented a report on the fixing of manufacturing limits in flanges and fittings threaded according to the Briggs standard. A report is before the Council recommending the appointment of a committee to act as a clearing house for all matters of standardization.

A spirited discussion resulted over the report of the Committee on Standardization of Flanges. This schedule, known as the "1914 Standard," which was reported in "Power," Oct. 14, 1913, represents a compromise between the 1912 standard, adopted jointly by the American Society of Mechanical Engineers and the Master Steam and Hot Water Fitters Association, and the 1912 Manufacturers' standard. Representatives of the Master Steam and Hot Water Fitters Association objected to the new schedule on the ground that the 1912 standard had already been adopted by various departments of the Government as well as several manufacturers who had already changed their patterns to conform to it. The association contended that it had not been given ample opportunity to express its views when the new schedule was being devised. It insisted that if a compromise schedule were to be provided the interchangeability feature of the 1912 standard should be retained and that it should be known as the "1912 Standard Revised to Jan. 1, 1914," instead of the "1914 Standard." Moreover it was urged that the larger size flanges should be adopted only after having been approved by the American Water Works Association and the New England Water Works Association.

The proposed new standard was defended by H. G. Stott and W. M. McFarland, both members of the A. S. M. E. committee, who challenged the opposing side to point out any engineering defects in the new schedule, and explained that the interests of everyone concerned would be best served through a compromise, thus doing away with the inconvenience of two standards. A motion was carried, however, to postpone definite action on the new standard until the next meeting of the society, meanwhile affording an opportunity for all factions to get together.

The first professional paper was "Notes on the Further Operation of Large Boilers of the Detroit Edison Co.," by J. W. Parker. Because of the importance of the subject, this paper will be abstracted rather fully in the next issue. Owing to the time consumed by the discussion upon the standardization of flanges, it was found necessary to hold over the rest of the papers scheduled for Wednesday morning until the following day.

In the afternoon three simultaneous sessions were held, one on railroad work, one on cement and one on textiles. The papers presented at the first were "Steel Underframe Box

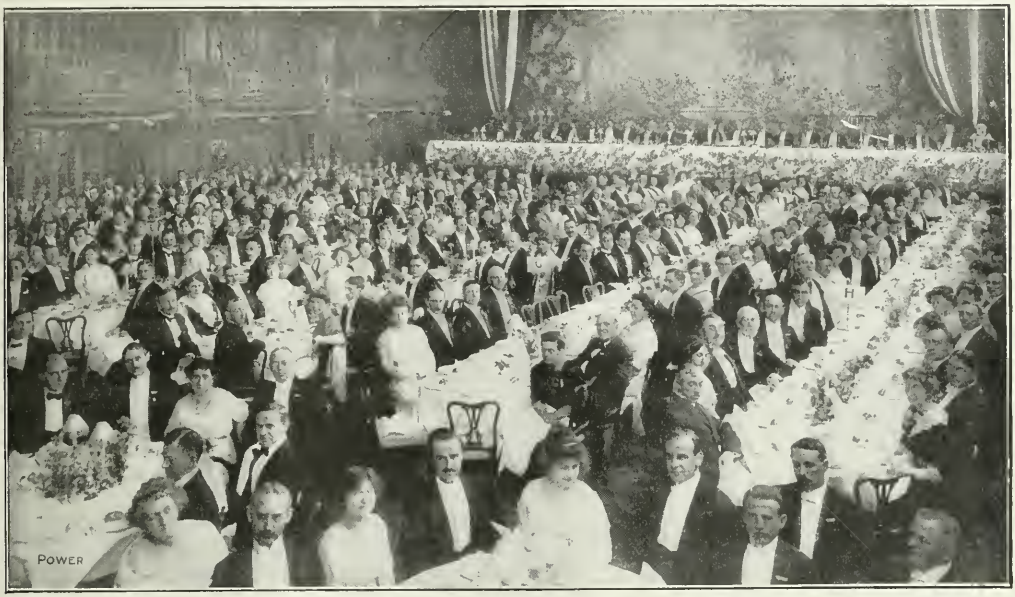
Cars," by George W. Rink, and "Steel Upper Frame Box Cars," by R. W. Burnett. No set papers were provided for the cement session, but opportunity was afforded for those interested in cement manufacture to gather for an informal discussion on various subjects.

The papers contributed by the subcommittee on Textiles included "Cotton Conveying Systems; their Safeguards Against Fire," by H. A. Burnham; "Specifications for Factory Timbers," by F. J. Hoxie, and "Textile Cost Accounting," by C. B. Annett and C. F. Cunningham.

For the ladies there was a reception, musicale and tea in the rooms of the society from 3:00 to 6:00 p.m. to which the members and guests were invited.

Wednesday evening was to have been the occasion of the presentation of the Grashof medal to George Westinghouse, past president and honorary member of the society, the award of which by the Verein Deutscher Ingenieure was made at the joint meeting of the two societies in Germany last summer, as mentioned already in these columns. Unfortunately illness prevented Mr. Westinghouse from being present.

There was no disappointment, however, in any sense of the word in the other feature of the evening's program, an address, illustrated by lantern views on "Leonardo da Vinci—Engineer and Artist," by John W. Lieb, Jr., past vice-president



German Dinner of the American Society of Mechanical Engineers, at Hotel Astor, New York City, Dec. 4, 1913

of the society. Renowned as was this great Italian for his achievements in the field of art, few appreciate that he is equally well entitled to a prominent place in the history of engineering and invention. It was a treat indeed and a revelation to many to hear of the extent of the contributions of Leonardo da Vinci to the earlier scientific knowledge.

THURSDAY SESSIONS

The deferred papers from the Wednesday morning session were given first attention at the general session Thursday morning in the auditorium, while simultaneously sessions on machine-shop practice and gas power were held in other parts of the building.

At the general session the papers were "Task Setting for Firemen and Maintaining High Efficiency in Boiler Plants," by Walter N. Polakov, an abstract of which will be presented later; "The Properties of Steam," by R. C. H. Heck, presented by title only, report of the Sub-Committee on Hoisting and Conveying; "Dynamic Braking for Coal and Ore Handling Machinery," by Clark T. Henderson; "Efficiency of Rope Driving as a Means of Power Transmission," by E. H. Ahara; "Comparative Tests of Three Types of Lineshaft Bearings," by Carl C. Thomas, E. R. Maurer and L. E. Kelso; "Pitot Tubes for Gas Measurement," by W. C. Rowse; "Tests of Vacuum Cleaning Systems," by J. R. McColl; "Tests Upon the Transmission of Heat in Vacuum Evaporators," by E. W. Kerr, and "The Art of Enameling, or the Coating of Steel and Iron with Glass," by Raymond F. Nailler.

The papers contributed by the Sub-Commiteee on Machine-Shop Practice at one of the other two sessions were "Gears for Machine-Tool Drives," by John Parker; "Cast Iron for Machine-Tool Parts," by Henry M. Wood; "A Record of Pressed Fits," by C. F. MacGill, and "Standardizing Machinery," by Fred H. Colvin.

One of the papers presented by the Gas Power Section, "A New Process of Cleaning Producer Gas," by H. F. Smith, was printed quite fully in the Gas Power Department in the last issue. The other, "Present Status of the Large Gas Engine in Europe," by Prof. P. Langer, is to appear later.

Thursday afternoon was left free for excursions and the ladies received in the rooms of the society.

The principal social feature of the meeting was the German dinner and the dance which followed it in the Hotel Astor. As nearly as possible the dinner duplicated the characteristics of the large dinners in Germany last summer when a delegation of some 300 members and guests of the society attended the joint meeting with the Verein Deutscher Ingenieure as reported in "Power," Aug. 5, 1913. Nearly five hundred sat down at dinner and another hundred came later for the illustrated lecture descriptive of the chief features of the German trip by Past-President Worcester R. Warner and the dance which followed. An extensive collection of lantern slides had been made from selections of the numerous snap-shots taken by those on the trip and these and the lecture brought back many pleasant recollections to those who were so fortunate as to have the privilege of being members of the party, while it gave the rest who did not attend somewhat of an idea of the lavish entertainment provided by the German hosts. Numerous speeches and toasts were offered during the dinner between courses and telegrams were read from those who had had a conspicuous part in the entertainment of the society, Dr. Oskar Von Müller, president of the Verein Deutscher Ingenieure, Dr. Conrad Matchoss, who came over in advance of the meeting to invite the American Society to attend and others. The speakers at the dinner were the retiring president, Dr. Goss, who introduced the toastmaster, Prof. L. P. Breckenridge, President-Elect Hartness, who in the absence of the president at the meeting was the official head of the party that went to Germany, Col. E. D. Meier, Prof. A. M. Greene, Jr., Sir Croyden Marks, a guest representing the Institution of Mechanical

[illegible] of Great Britain, A. E. Clifford, who had some apt [illegible] ly uses cast in the Kipling and Longfellow molds, and Secretary Calvin W. Rice, whose toast was "The Ladies."

FRIDAY SESSIONS

Friday morning the last professional session was held in the auditorium with a group of papers contributed by the Sub Committee on Fire Protection. These were "The Fire Hazard in Turbo-Generators," by G. S. Lawler, an abstract of which will be given in a later issue; Extinguishing of Fires in Oils and Volatile Liquids," by Ed. A. Barrier; "Control of Automatic Sprinkler Valves," by Fred J. Miller; "The Need of More Care in the Design and Construction of Elevated Tanks," by W. O. Teague, and "Fire Pumps," by Ezra E. Clark.

At the conclusion of this session the usual vote of thanks to the various committees, individuals and companies, who had contributed to the program of papers and excursions was passed, acting upon a resolution offered by George I. Rockwood.

EXCURSIONS

Friday afternoon was left open for participating in excursions, and others were made throughout the meeting. Among the more important of these were those to the Catskill Aqueduct tunnel construction plants, the Waterside station of the New York Edison Co., the power plant of the Interborough Rapid Transit Co., the Woolworth building and power plant, the "Kaiserin Auguste Victoria," of the Hamburg-American Line, the Pennsylvania R.R. terminal, the Grand Central terminal, the Brooklyn Navy Yard, the National Lead Co., the Tidewater Paper Co. and the E. W. Bliss Co., in Brooklyn, and the Davis-Bouronville company's factory for the manufacture and demonstration of oxy-acetylene welding and cutting equipment, at Jersey City, N. J.

BOTH SIDES OF THE GRASHOF MEDAL AWARDED TO GEORGE WESTINGHOUSE

A number of college reunions were arranged for Friday evening, which was a new feature for an annual meeting. The alumni of Stevens Institute of Technology had a theater party, supper and dance, those of Worcester Polytechnic Institute their annual dinner, and reunion dinners were held by the engineering alumni of the Polytechnic Institute of Brooklyn, Yale University, Cornell University, Kentucky State University and Brown University.

Believes in Safety First

One hundred and fifteen factory foremen of the Goodyear Tire & Rubber Co., Akron, Ohio, have been organized into a compact and aggressive "safety first" battalion. This organization was perfected at a banquet presided over by President F. A. Seiberling and addressed by him and other Goodyear officials, as well as outside experts of note. President Seiberling said: "During the past year, 8000 men have worked for Goodyear, and the coming year this number will be increased to 10,000. It is inevitable among such a multitude that accidents will happen, therefore our foremen need to realize the necessity of safeguards and constant vigilance. This company holds the safeguarding of the lives and well-being of its employees as a high moral obligation."

Moving pictures showing safety devices and the danger of their absence, illustrated various talks. A squad was organized to patrol the 41-acre factory constantly, looking for dangerous operations, instructing workmen, and suggesting safety devices.

Installed but a short time, this "safety first" organization has already caused a noticeable reduction in the number of minor accidents reported among the thousands of the Goodyear Co.'s workmen.

Purifying Apparatus Suit Decided

A final decision from the ultimate court has just been rendered at Cincinnati sustaining the patent of J. C. W. Greth for water-purifying apparatus.

The suit was originally filed before Judge Evans, at Louisville, Ky., in July, 1910, by Wm. B. Scaife & Sons Co., of Pittsburgh, Penn., against the Falls City Woolen Mills, Louisville, Ky., who had installed a continuous water-softening system alleged to be manufactured and furnished by the Fetta Water Softener Co., Richmond, Ind. The Louisville court denied the injunction and appeal was taken to the court of appeals at Cincinnati, which has now reversed Judge Evans, upholding the validity of the patent, and ordered the usual decree for injunction and accounting and recovery of damages.

Marine Engineers' Annual Event

On the evening of Dec. 3, at the Lexington Opera House, Marine Engineers' Beneficial Association No. 33 held its annual entertainment, ball and reception. The arrangement committee included W. J. Du Bois, James O'Keefe, Thomas J. Quigley, J. M. Sterritt, L. F. Oliver, James Moran, Richard Aiken and T. L. Delahunty. Frank Martin was the floor director and Frantzen's orchestra provided the music.

The hit of the entertainment was the minstrel show of the "M. E. B. A. Bunch." John Lloyd Wilson was the interlocutor, and the end men were Monroe Silver, Billy Murray, Ed Meeker and Joe McKenna. Others in the "Bunch" who contributed to the evening's enjoyment were M. J. O'Connell, Jack Armour and F. J. Corbett. Part II of the program included Madeleine Livingston, Whalen, West and Whalen, Matt and Jessie Shaefer, George Andrews, and Clark and Watson.

Change in Chicago Light Rates

In extending on Nov. 26, the franchise of the Commonwealth Edison Co., the city council of Chicago voted to accept the change in electric-lighting rates offered by that corporation. The old rates were 10c. per kw.-hr. for current used up to that quantity which would be consumed by 30 hr. use of the maximum number of lights used and 5c. per kw.-hr. for all consumption in excess of this. The new rates provide for a tertiary charge of 4c. per kw.-hr. for all current in excess of the consumption which would be due to 60 hr. use of the maximum number of lights used. This rate became effective on Dec. 1 and is to be reduced to 3c. on Mar. 1, 1914. The old primary charge of 10c. per kw.-hr. for the first 30 hr. remains while the secondary charge of 5c. is made for the second 30 hr.

It is estimated that the change will not affect some 40,000 small consumers, of the 150,000 customers served, as their service requirements are such that the tertiary rate never becomes effective.

A small faction in the council stood out for a reduction of 1c. in the primary rate and ½c. in the secondary, so that the benefit might be equably distributed among all consumers, both large and small. This faction also urged a franchise period of three years instead of the five granted.

Appropriations to the Bureau of Mines for Coal and Gas Testing

The estimates of appropriations for the United States Bureau of Mines, for the fiscal year ending June 30, 1915, as approved by Secretary Lane of the Interior Department, have just been forwarded to Congress. They total $752,000, and out of this $10,000 is for the equipment of the testing plant at Pittsburgh, $135,000 for testing fuels, and $30,000 for inquiries and investigations of petroleum and natural gas.

The $10,000 asked for the equipment of the testing plant is a new item. The money is needed for the purchase of steam and electric equipment. The estimates set forth that the present power and electric service plant at the experiment station is on the eve of breakdown.

The item of $30,000 for inquiries and investigations of petroleum and natural gas is for the first time placed separately in the estimates and represents an increase. It calls for inquiries and investigations concerning the mining, preparation, treatment and utilization of petroleum and natural gas, with a view to economic development, and conserving resources through the prevention of waste. On this subject, the estimate contains the following statement:

In 1911 the total value of the petroleum produced in this country was $134,044,752; that of the natural gas usefully produced was $74,127,534. The magnitude of the petroleum industry, the increasing value of petroleum and natural gas

as fuel, and the rapid decline of the yield from many fields emphasize the need of conducting inquiries concerning the mining, treatment and utilization of petroleum and natural gas, with a view to economical and efficient development of these resources, as well as inquiries into the economic conditions that have developed in the oil and gas industries, with a view to the determination of the factors governing production and the means whereby supplies of oil and gas, especially those on public lands or on lands controlled by the Government, can be utilized to best advantage in promoting the public welfare.

As illustrating the need for inquiries and investigations concerning petroleum and natural gas, with a view to economic development, it is pertinent to note the following extract from a recent report received by the Bureau of Mines regarding the Cushing field of Oklahoma: "The maximum yield of oil from the Cushing field has never reached 30,000 bbl. per day. For a long period it has been considerably less than 20,000 bbl. per day. The average value of oil at the highest market quotation probably lies below $20,000 per day. During this time there has been wasting from drilling wells not less than 100,000,000 cu.ft. of gas, while the waste from flowing wells is perhaps in excess of 200,000,000 cu.ft., making a total daily waste of 300,000,000 cu.ft., which, at the domestic rate of 25c. per 1000 cu.ft., would be $75,000 per day in fuel, or a matter of perhaps $20,000 a day to the oil producer. It is not only possible to conserve this gas, but it also is possible in many cases to so manage the wells that they can furnish oil without allowing the gas to escape. The main purpose of the oil producer is to get the oil and let the gas escape." There are other fields in the United States where enormous daily waste of gas occurs.

Practically all the oil purchased by the different branches of the service of the United States has been tested by the Bureau of Mines. This is particularly true of tests for the Navy Department, these purchases amounting during the past year to about 21,000,000 gal. of oil.

Germany Will Exhibit at the Fair

A Berlin dispatch says that, "Despite the aloofness of official Germany regarding the Panama-Pacific Exposition in San Francisco in 1915, there is ground for the belief that Germany will send the biggest exhibit in her history to the exposition. Arrangements have already been made by 1400 large firms to show their wares which the great shipping lines will convey to the Pacific free of cost. A petition is about to be presented to the Reichstag by the Independent San Francisco committee asking for an appropriation of $500,000 for a German building at the exposition, saying that an adequate display is of vital necessity to German industry. Otherwise, the petitioners say, Great Britain will be allowed to crowd Germany out in the markets of North and South America, especially in regard to textiles and machinery.

The petition says Germany has no right to boycott the exposition in consequence of an agreement with Great Britain.

It is believed the object of the petitioners is supported by a sufficiently strong body in the Reichstag to insure the voting of the appropriation.

Manufacturers and Engineers Visit Mesta Works

The Engineers Society of Western Pennsylvania and other prominent engineers and iron and steel manufacturers visited the works of the Mesta Machine Co., West Homestead, Penn., Saturday afternoon, Nov. 29, by special train, there being about 250 in the party.

The principal object of the visit was to inspect the 46-in. slabbing mill, the 44 and 76 by 60-in. twin-tandem-compound geared reversing engine and the 44x60-in. three-

Engineers Society of Western Pennsylvania and Other Prominent Visitors at the Works of the Mesta Machine Co.

cylinder reversing engine which the Mesta Machine Co. has designed and built for the Gary Works of the United States Steel Corporation. The large engine is capable of developing 25,000 hp. and weighs about 1000 tons. The total weight of the mill and engines is about 4250 tons.

The mill will be used at the Gary Works for rolling large steel ingots up to 50 tons in weight, into slabs for the other finishing mills. The rolling mill is said to be the largest of its kind in the world. Some of the castings in this equipment weigh about 90 tons, and it will require 85 cars to transport it to the Gary Works at Gary, Ind.

The Mesta Machine Co. is running to full capacity and at present has enough orders on its books to keep it busy at full capacity for some time to come. Several of the principal orders on hand are for a large twin-tandem compound reversing engine for Corrigan, McKinney & Co., Cleveland, Ohio, and two large cross-compound blast furnace blowing engines for the Woodward Iron Co., Woodward, Ala., and some rolling mills for the Bethlehem Steel Co. The company also has orders for some rolling-mill equipment for the Canadian Car & Foundry Co., Fort William, Ont., and the Imperial Steel Works of Japan.

RECEPTION OF THE COMBINED ASSOCIATIONS OF ENGINEERS OF BROOKLYN

New York "Museums of the Peaceful Arts"

Steps have been taken to found a group of museums in New York City, to be known as "The Museums of the Peaceful Arts." The group is to consist of 20 buildings, and when completed will constitute the greatest institution of its kind in the world.

A site is to be procured sufficient to meet the needs of the entire project, but in the beginning only one or two buildings will be erected. The entire cost of the group is estimated at about $30,000,000, and the annual maintenance charges at between $2,000,000 and $3,000,000.

It is proposed that the museums shall be divided into the following branches: Electricity, steam, astronomy and navigation, safety appliances, aviation, mechanical arts, agriculture, mining, labor, efficiency, historic records, health and hygiene, textiles, ceramics and clays, architecture, scenic embellishment, gardening, roads and road-building materials, commerce and trade, printing and books. In addition there will be a central library containing books and periodicals relating to the subjects of the museum.

This is the first project looking toward the establishment of a museum of science and industry to take definite form in the United States. The outline is splendid in its breadth and scope; if carried through to completion, this museum will be a worthy companion of the two other great museums in New York City.

SOCIETY NOTES

The American Association for the Advancement of Science will hold its sixty-fifth meeting at Atlanta, Ga., on Dec. 29 to Jan. 3.

The Marine Engineers' Beneficial Association will hold its 39th annual convention in Washington, D. C., beginning Dec. 19 and concluding on Dec. 24. The Raleigh will be the headquarters. A large attendance of delegates and guests has been promised.

About the middle of January the Chicago Section of the American Society of Mechanical Engineers will hold a meeting having for its subject "Steam Power Plants." The speakers will be men in charge of some of the largest power plants in the country. At the section's dinner meeting, Nov. 19, there was an attendance of 162 members and guests.

The annual masque and civic ball of Local No. 56, International Union of Steam and Operating Engineers, was held on Saturday evening, Dec. 6, at Brooklyn Labor Lyceum. The attendance was large and the costumes were attractive. The reception committee was composed of Frank H. Schmitz, chairman; Charles Freiermuth, Charles F. Liebmann, Joseph Munterfering and Conrad Ehle.

On Saturday evening, Dec. 6, the sixth annual entertainment and reception of the Combined Associations of Engineers in the Borough of Brooklyn was held in Kismet Temple, and was most successful. Delegates were present from Local Associations Nos. 8, 27, 41, 57, Melville Council No. 9 and the Modern Science Club. The reception committee included G. W. Roff, J. O. Westberg, William Smith, Charles Schabacker, W. F. Brundage, C. A. Enggren and G. O. Kaley. Frank Martin was floor manager. On the entertainment program were Nichols Brothers, Madeleine Livingston, the Schaefers, Harry Burgoyne, Allen and Dalton, the New York Quartet, Larry Sharkey and Clark and Watson.

PERSONALS

Irvin S. Chamberlain, a member of No. 2 Association, N. A. S. E., of Paterson, N. J., has been appointed chief engineer of the new United States Post Office Building at Jersey City.

John A. Drew, for over 25 years the New York sales manager for Henry R. Worthington and the International Steam Pump Co., has accepted the position of specialties' sales agent with the Epping-Carpenter Pump Co.

H. M. Montgomery, for many years the Western representative of the Alberger Condenser Co., has been appointed the Western representative of the Permutite Co., which exploits a new water-softening and scale-preventing process.

POWER

Vol. 38 NEW YORK, DECEMBER 23, 1913 No. 26

Atlantic City Pumping Plant

By Warren O. Rogers

SYNOPSIS—Fire destroyed the old nonfireproof pumping plant, but disabled the plant machinery only 19 hr. while repairs were being made. The present building is fireproof throughout. The pumps are of several designs, but the old units will ultimately be replaced by more modern pumping engines. Provision has been made in the pipe-line construction to prevent a possible disabling of all boiler or pumping units. Three sources of feeding the boiler have been provided.

Atlantic City, N. J., with an estimated resident population of 55,000, and during the summer months with an estimated population of from between 125,000 and 200,000 is confronted by a condition encountered by but few if any cities of similar size. Although the population during the winter is but one-fourth of that of summer, the pumping equipment of the city pumping plant must be of sufficient capacity to supply the demands the year round; hence the capacity of the pumping apparatus is necessarily greater than would be required under ordinary circumstances.

During the year of 1912 the average amount of water pumped per day was 9,774,200 or 3,567,583,000 gal. for the year. It is during the months of July and August that the maximum consumption occurs, which for one day was 14,057,000, and for one month was as high as 12,291,000 gal. per day. An approximate maximum rate for one day has been as high as 16,000,000 gal.; approximated because the maximum capacity of the meter was 14,000,000 gal. per day.

Prior to 1895 water was supplied to the city by two private water companies. Both systems, however, were purchased by the city and in 1904 all water was supplied from the Absecon pumping station. This plant was destroyed by the fire in the latter part of 1909, and the new

Fig. 1. Atlantic City Pumping Plant

plant was erected on the site of the old, and was completed in 1911. The old building was of wood, brick walls, wood floors and roof, and, although completely destroyed, the machinery was damaged but slightly. In fact, due to the efforts put forth by the engineers, the system was out of service but 19 hr., while the débris was being cleared away and necessary repairs to pipe lines, etc., were being made. The boiler and pumping units were protected by a temporary shelter while the new building was being built.

In Fig. 1 is a view of the new fireproof building. It

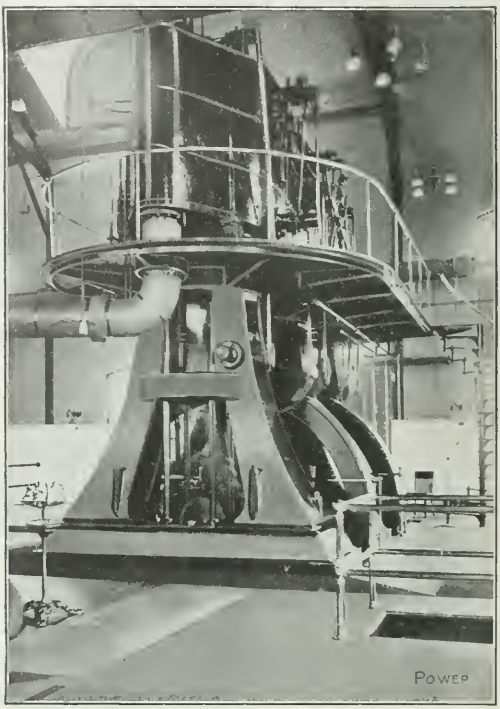


Fig. 2. The 12,000,000-Gal. Triple-Expansion Pumping Engine

is of red brick; the inside is finished with a white-enameled wainscoting of such a height that when the floors, which at present are on two levels, are made the same the finish of the walls will be uniform; the upper walls are painted cream color. The upper floor is finished in red tile; the lower floor is of concrete. The building is 70x80 ft. with a reinforced-concrete roof supported by steel trusses.

Upon the upper floor of the pump room, which is 40 by 70 ft. in dimension and is 6 ft. above the lower floor, contains one vertical, triple-expansion, condensing, crank and flywheel, triple, single-acting pumping engine. The steam cylinders are 19¼, 36 and 52 by 36 in. with water plungers 24¾ in. in diameter. The pump, Fig. 2, runs at 38 r.p.m., and has a capacity of 12,000,000 gal. per day. The water cylinders are in the basement, which is separated from the lower floor level by a concrete wall. On the same floor level is a 10,000,000-gal., turbine-

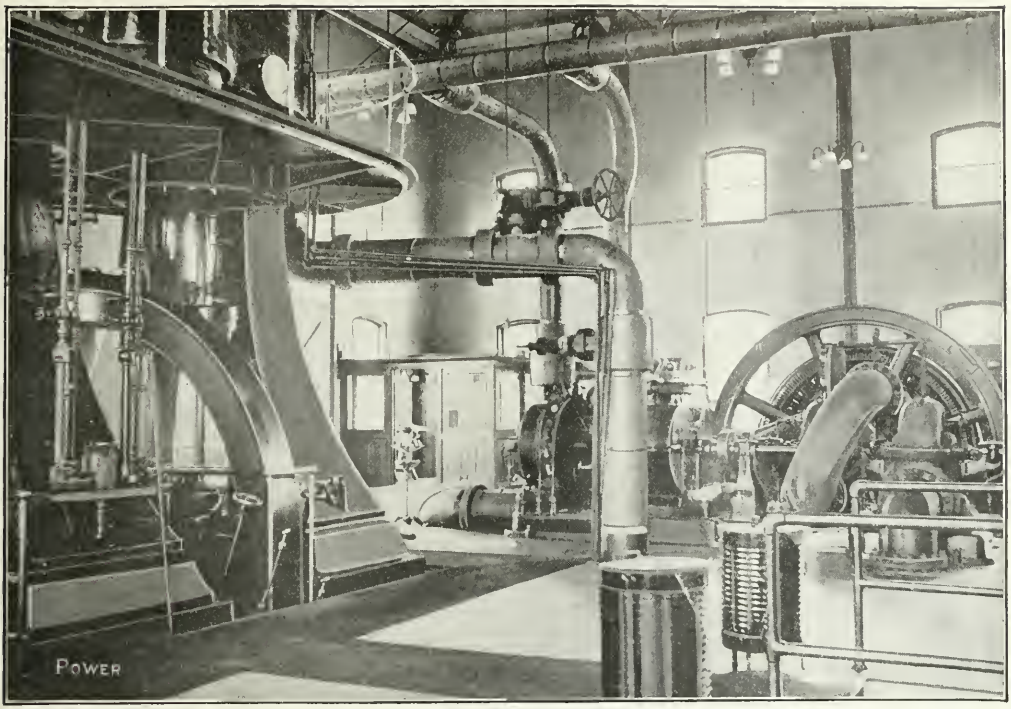


FIG. 3. PARTIAL VIEW OF THE UPPER FLOOR, WITH VERTICAL PUMP IN THE FOREGROUND, TURBINE-DRIVEN CENTRIFUGAL PUMP AND ENGINE-DRIVEN GENERATOR AT THE RIGHT

driven, two-stage, centrifugal pump. This unit is shown in Fig. 3. The 300-hp. turbine drives the pump at 850 r.p.m.

In the basement, under the last mentioned units is a 40-hp. turbine-driven, single-stage centrifugal pump with a capacity of 5,000,000 gal. per day at 850 r.p.m. It has a lift of 25 ft. This unit pumps from the driven wells to the high-pressure pump reservoir.

On the lower floor are two horizontal, cross-compound condensing compressors with steam cylinders 10 and 16 and 11 and 18 in., air cylinders 14 and 16 in., and 12- and 14-in. stroke respectively. The air pressure is 25 lb. per sq.in., and the units have a rated capacity of 600 and 1000 cu.ft. of air per min. respectively. With the air compressors on the lower floor level are the three compound reciprocating pumps, Fig. 4. The largest of the reciprocating pumps has a capacity of 6,000,000 gal. per day at 18½ r.p.m. with cylinders 21, 40 and 21½ by 36 in. The next largest pump is of 3,500,000 gal. capacity, having cylinders 16, 24 and 18 by 18, running at 31 r.p.m. The smaller unit is of 3,000,000 gal. capacity and has cylinders 10, 18 and 12 by 16 in.; it runs at 59 r.p.m.

During the winter months water is pumped by the large flywheel pump, but in summer two of the three large pumps are in service to meet the increased demand for water.

BOILERS

The plant is divided into three parts, the pump room and two boiler rooms, which are at one end of the main

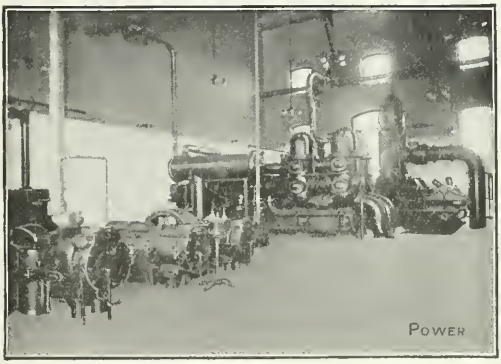


FIG. 4. AIR COMPRESSORS AND CONDENSING RECIPROCATING PUMPS

part of the building. The boiler room forms an ell portion of the plant, and contains six water-tube boilers. Two are of 125-hp., two of 200- and two of 300-hp. rating with 33, 49 and 51 sq.ft. of grate surface respectively. The 200-hp. units have 2000 sq.ft. of heating surface, the 300-hp. units, 2931 sq.ft. The pressure carried is 125 lb. The 125- and 200-hp. boilers are in the boiler room at the end of the pump room, Fig. 5, and the two 300-hp. boilers, Fig. 6, are in the ell portion with room for two more of similar capacity.

All boilers are set in batteries of two and are fed by duplex boiler-feed pumps of which there are two with 6 and 4 by 6-in. cylinders and one with 10 and 6 by 10-in. size. Two of these pumps are in No. 1; the larger one in No. 2 boiler room. Each pump rests on a concrete foundation 18 in. above the floor level. Two injectors

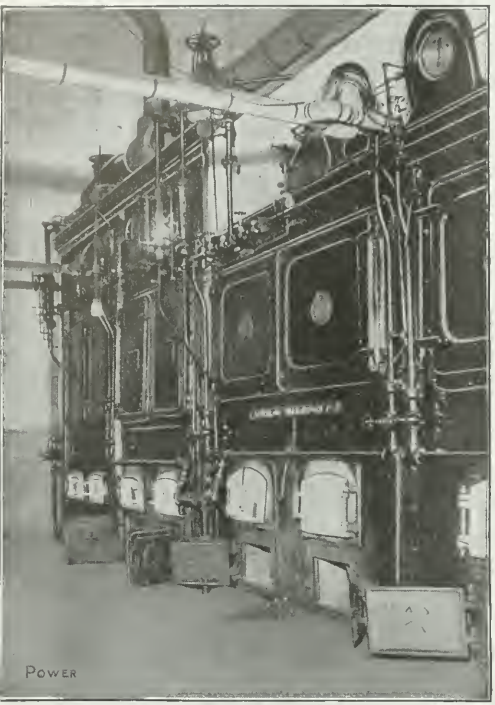


FIG. 5. FOUR OF THE SIX WATER-TUBE BOILERS

are also piped up to be used in emergencies if the pump should become inoperative.

All feed water is metered by either of two meters placed between the feed pumps and the 600-hp. open heater. The meters are arranged for bypassing in case repairs are necessary.

All doors communicating with the boiler room are single metal automatic fire-doors. At the rear of each battery of boilers is a set of large double doors opening to the outside of the building, which is exceedingly convenient in case it is necessary to remove old or install new boilers. Provision has also been made for an additional heater without change of piping by the removal of a flange on the 14-in. vertical, exhaust-steam pipe.

Bituminous coal is delivered to the plant by teams under contract from the railroad, 1½ miles distant. It is dumped into the hopper of a coal conveyor, which discharges it into a concrete coal pocket of 400 tons capacity. An industrial track runs from in front of the boilers to beneath a discharge opening in the bottom of the coal pocket, through which coal is discharged into 1-ton metal charging cars.

WATER SUPPLY

Water pumped by the station is obtained from twenty-one 10-in. wells, provided with 8-in. strainers and 6-in. suction pipes, and driven 100 and 200 ft. to different strata. One line of 10 wells is operated by an air lift, air being supplied by the two compressors already mentioned. The supply of water from this group is at least 2,000,000 gal. per day. A second group of wells is connected to the centrifugal pump installed in the basement under the electric-generating unit. The pump delivers at a low head into a flume leading to one of two receiving wells. The capacity of this group of wells is about 3,000,000 gal. of water per day.

At the end of the wooden conduit is a basin with sloping sides. It has a normal capacity of 700,000 gal. This basin is connected with the north pump well by a 300-ft. wooden flume. Midway of the flume a 20-in. cast-iron main runs to the artesian basin and a wooden flume to the south pump well. The basins act as an additional water supply to the normal water supplied by the wells.

Beside the wells there is a surface supply for a watershed 18 sq.in. in area. The maximum runoff of Absecon Creek is about 7,500,000 gal. per day. All water pumped is metered. The meter has a rate-flow dial, a daily chart and a register.

PIPING

In Fig. 7 is shown a general plan of the live and exhaust steam and water piping of the plant. Above the front end of the boilers in No. 1 boiler room is an 8-in. header to which the four boilers are connected by 5- and 7-in. lead pipes from the 125- and 200-hp. boilers respectively. These lead pipes are equipped with a stop and a nonreturn valve placed in the line close to the 8-in. header. The 300-hp. boilers are piped through nonreturn valves and stop valves in the 7-in. leads to a 10-in. header which runs along the wall separating the boiler and pump rooms. The 8- and 10-in. headers are tied together by a 4- and 6-in. pipe, each provided with stop valves so that any section of header connected to any particular battery of boilers can be cut out of service. In like manner the

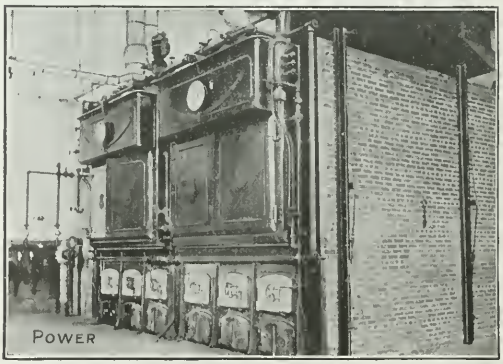


FIG. 6. TWO 200-HP. WATER-TUBE BOILERS

boilers and that part of the 10-in. header in No. 2 boiler rooms can be cut out of the line.

The 6-in. steam line in the pump room is of the loop design. It is connected to the 10-in. header, as indicated and runs to the far end of the pump room, returning about midway of the room, and connecting to the outer end of the 10-in. header. A 5-in. branch pipe supplies

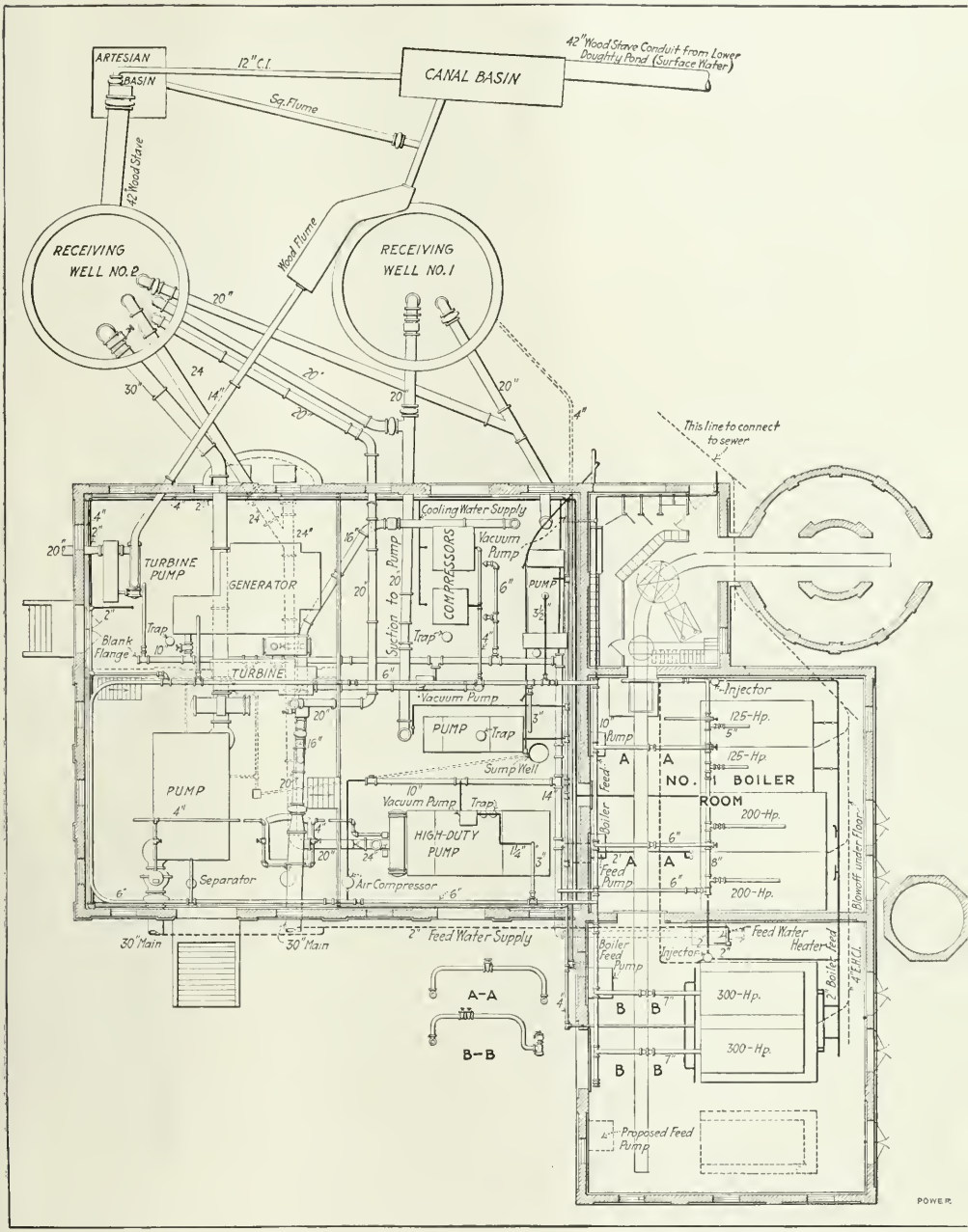


Fig. 7. Plan of the Atlantic City Pumping Plant, Showing Piping and Equipment Layout

through the 4-in. underground line to which each pump is connected by a 2-in. pipe for the smaller pumps and a 3-in. pipe from the larger pump. A third source of feed-water supply is by the two injectors, which discharge through a 2-in. line to the rear of the drum of the boilers. This system calls for two feed headers at the boilers, one above the firing floor, the other in front of the steam drums and above the boiler fronts. These 2-in. headers are connected at the ends and so fitted with valves that various combinations can be made to maintain the boiler feed in case of accident to either of the feed lines.

The pump-room basement is encircled by two pipe lines. One is of 4 in. diameter and supplies water for priming the various pumps through branch lines. The other pipe line is provided with valves and connections for 1-in. hose and supplies hot water for washing down the floors, etc. The waste water goes to a hotwell and is discharged to waste.

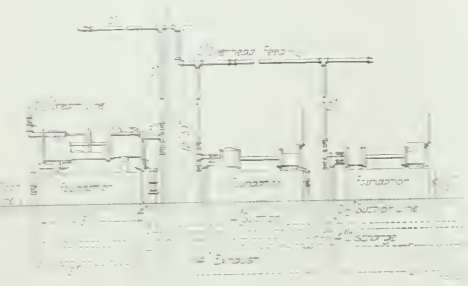


FIG. 8. PIPING OF THE BOILER-FEED PUMPS

MISCELLANEOUS

Operation of the station is by two shifts of 11 and 13 hr. respectively. Metal lockers are provided for the men and hot and cold water in the wash room, where there is a shower bath and toilets.

At the end of the boiler house is a small machine shop for making light repairs. The machines are driven by a 7½-in. vertical steam engine. A stock room contains metal bins for pipe fittings, etc. A first-aid cabinet, for possible injuries is placed where it is easily accessible.

The building is illuminated by 96 sixty-watt tungsten lamps, the fixtures being of verdi antique finish. Flush wall receptacles at various points for extension cords furnish convenient light for repair work about the pumps.

Contemplated improvements at the plant include the installation of a centrifugal pump to displace the air compressors and putting in two more 12,000,000-gal. pumps to replace the old reciprocating pumps, and to also pro-

PRINCIPAL EQUIPMENT OF THE ATLANTIC CITY PUMPING PLANT

	Equipment	Kind	Size	Use	Operating Conditions	Maker
1	Pump	Triple expansion	9½, 36 and 52 by 36"	Main pumping unit	Condensing, 125 lb. pressure, 38 r.p.m.	Bethlehem Steel Co.
1	Pump	Centrifugal 2-stage	1,000,000 gal.	Emergency fire unit	Turbine driven, 850 r.p.m.	De Laval Steam Turbine Co.
1	Turbine	De Laval		Drives 1,000,000 gal. centrifugal pump	Condensing, 125 lb. pressure, 850 r.p.m.	De Laval Steam Turbine Co.
2	Engine	Corliss	10x30"	Drives alternating generator	Condensing, 125 lb. pressure, 120 r.p.m.	Bates Machine Co.
1	Generator	Alternating current	15 kv.a.	Station lighting	Three-Phase, 60 cycles, 120 r.p.m.	Fort Wayne Electric Co.
1	Turbine			Drives low-lift centrifugal pump	Condensing, 125 lb. pressure, 850 r.p.m.	
2	Pump	Single stage centrifugal	5,000,000 gal.	Pumps from wells	Turbine driven, 850 r.p.m.	Platt Iron Works
1	Compressor	Horizontal	10, 16 and 24 by 12"	Well air lift	600 cu. ft. capacity, 12 r.p.m.	Ingersoll-Rand Co.
1	Compressor	Horizontal	11, 18 and 18 by 14"	Well air lift	1,000 cu. ft. capacity, 14 r.p.m.	Ingersoll-Rand Co.
1	Pump	Compound duplex	21, 44 and 21 by 36"	Main pumping unit	Condensing, 18½ r.p.m.	Henry R. Worthington
1	Pump	Compound duplex	18, 34 and 18 by 18"	Main pumping unit	Condensing, 31 r.p.m.	Laidlaw-Dunn Gordon
1	Pump	Compound duplex	10, 18 and 12 by 18"	Main pumping unit	Condensing, 56 r.p.m.	Laidlaw-Dunn Gordon
2	Boilers	Water tube	125 hp.	Steam generators	Hand fired, 125 lb. pressure	National Boiler Works
2	Boilers	Water tube	175 hp.	Steam generators	Hand fired, 125 lb. pressure	E. Keeler Co.
4	Boilers	Water tube	200 hp.	Steam generators	Hand fired, 125 lb. pressure	Heine Safety Boiler Works
1	Pump	Duplex	Special 10"	Boiler feed	Variable speed	Henry R. Worthington
1	Pump	Duplex	4x4x6"	Boiler feed	Variable speed	Henry R. Worthington
2	Meters	Thermal			Continuous	Hersey Mfg. Co.
1	Heater	Open	400 hp.	Feed water	Exhaust steam	Harrison Safety Boiler Wks.
4	Chimney	Radial brick	125 ft. high, 6 flues	Flue gas	Natural draft	Heine Chimney Co.
1	Injector	Sellers		Spare boiler feed	High pressure	Wm. Sellers & Co.
1	Motor	Vertical	10 kw.	Starting water pump		Builders Iron Foundry Co.

*The steam connection to the two 4x4x6" pumps is 3 in. while the steam connection to the 4x4x6" pump is 2 in.

duct from the boiler-feed pumps also discharges into the 14-in. exhaust line. The heater is connected with a 4-in. atmospheric exhaust line.

The piping of the boiler-feed pumps is shown in Fig. 8.

The sources of boiler feed are obtained from each pump through the 2-in. overhead line: the other pump can furnish the 2-in. overhead line; the other pump can furnish the additional pump capacity for the increasing demand on the station.

The writer is indebted to L. C. Manz, assistant engineer and superintendent, who designed the new pumping station, and to Harry Bacharach, Director of Parks and Public Property, in whom the supervision of the department is vested, for data contained herein.

L. Van Gilder is engineer and superintendent.

Task Setting for Firemen

Walter N. Polakov, in a paper presented under the above title, at the recent meeting of the American Society of Mechanical Engineers, describes an investigation made under his direction of the fire-room methods employed at the Warrior Ridge Station of the Penn. Central Light & Power Co., the methods adopted to improve the efficiency and the results obtained. He proceeds at first to determine the maximum efficiency of the plant under operating conditions, and then to provide that this efficiency shall be maintained, not during a few hours or days that the test is being run, but continually.

The well known fact that the high efficiency attained by experts during the boiler tests is seldom maintained in everyday practice is due to gross neglect on the part of the management to:

a. Record the conditions causing the high efficiency during the tests.

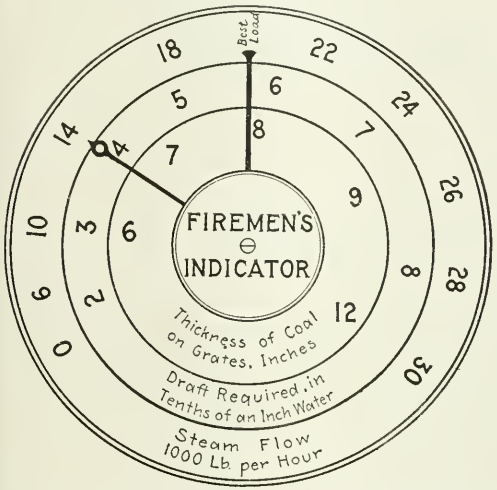

Best Load
FIREMEN'S
INDICATOR
Thickness of Coal on Grates, Inches
Draft Required in Tenths of an Inch Water
Steam Flow 1000 Lb. per Hour

FIG. 1. DIAL OF STEAM-FLOW METER WITH SPECIAL SCALES FOR USE AS FIREMAN'S INDICATOR

b. Instruct the men how to regulate these conditions in order to duplicate the test results, and

c. To provide an incentive to the men for striving for the purpose desired by the management or owners.

A continuous test extending over 80 days, made to determine the results of the existing practice, indicated a combined efficiency of boiler and grate of 52.37 per cent. A 13-hr. test, during which a deliberate attempt was made to make a favorable showing under those conditions, resulted in an efficiency of 67.94 per cent. Analysis and improvement of these conditions raised this efficiency to 77.66 per cent., which was adopted as the practical maximum for this plant.

The next question was to ascertain what would be the reasonable limit below which no fireman should allow his efficiency to drop. In this connection the factors beyond the control of the fireman were to be considered, viz., sudden fluctuation of load and impracticability to analyze gases every few minutes, drop of attention every 40 min. for a period of 11 to 20 min., and the effect of cooling off heating surface and furnace walls during the cleaning of fires (the allotted time for this was set on time study as 18 min. per 100 sq.ft. of grate surface). On the other hand, there was made a correction for blowing off the boiler once in every 24 hr. which credited the boiler with so much metered water and debited it with so many heat units in the same amount of water at the boiler temperature. As a result of these investigations and studies it was found that the standard for the task should be set at 70 per cent. combined boiler and grate efficiency.

It is interesting to note that all the officials of the concern, and the representative of the boiler maker, considered the task on this basis too high, and that accomplishment of it would be out of the question. The only argument that obtained its temporary approval was that it was easier to reduce the task in the future, if not feasible to accomplish it, than to make it higher. The fourth month of the test work, however, proved that 73.1 per cent. of boiler and grate efficiency was permanently maintained, effecting for the company a gross saving of approximately 25 per cent. on the fuel bill alone. This was accomplished without heavy investment for improvement of equipment like automatic stokers, special grates, force-draft fans, soot blowers, etc. The only expense was for a few instruments for the guidance of the firemen in their work of living up to the instruction card.

As, with other conditions equal, the weight of steam is in direct proportion to the weight of fuel burned, the first instrument necessary for informing the firemen as to how much coal to put in the furnace, is a meter indicating the output of the boiler, but as this proportion is constant only at a given condition of combustion, the firemen have to be informed at all times as to what these conditions are. Since complete combustion requires a strictly defined quantity of air per pound of fuel of given composition, we have to know

a. Composition of fuel.

b. Rate of firing.

c. Rate of air supply.

In most cases it is possible to obtain fuel of practically uniform analysis, so that the first variable may be taken as a constant. The rate of firing is indicated by the steam-flow meter inasmuch as conditions of combustion are uniform. The last factor, then, the quantity of air to be supplied per minute to the furnace, is the factor which must be controlled.

This reasoning leads to the conclusion that for practical guidance the fireman needs at least three instruments:

a. Indicating steam meter.

b. Draft gage.

c. Indicator for the coördination of the condition of firing with the load carried by the boiler at any moment.

The author found the General Electric steam-flow meter of the indicating type satisfactorily to serve the third mentioned purpose. He arranged on the dial of the steam-flow meter an inside dial, as shown in Fig. 1, with numbers indicating the required thickness of fuel bed corresponding to the number of pounds of steam drawn

from the boiler, and a third dial with numbers indicating the draft which is necessary and sufficient to supply the required quantity of air for the combustion at a rate called for by the indicated steam demand. Thus if the pointer, as in Fig. 1, shows that steam is flowing from the boiler at a rate of, say, 14,000 lb. per hour, the fireman will know that the figure four under the pointer on the middle scale means that a draft of 0.4 in. of water is needed, and that the location of the pointer on the inner scale between the figures six and seven calls for a thickness of fires of from 6 to 7 in.

The next information vitally important for the fireman is the frequency with which his furnace must be coaled to keep the fire in best condition. The method adopted by the Italian Navy is accepted by the author as most satisfactory, consisting chiefly in bell signaling at intervals in proportion to the load carried by the boilers, which signaling is regulated by clock mechanism connected with a flow meter. For this purpose the counter of the feed-water weigher supplying water to the entire boiler house rings the bell every time a certain number of thousands of pounds of water is fed to the boilers, thus giving notice to the fireman that an adequate number of shovelfuls must be thrown into each furnace. This number is easily determined, since the weight of a shovelful of coal is known, and the rate of apparent evaporation at the given condition of firing is a constant.

Consideration is then given to the calculation of the different efficiencies.

Various schemes have been used as the basis of task setting for firemen, which, to the author's knowledge, have always created dissatisfaction. Certain of these are as follows:

A. The cost of steam generated was used for the basis of the task in the boiler room of a large cement plant, and a premium offered for the reduction of this cost, but as the firemen have no control over the purchase of fuel, maintenance of equipment, etc., as this task involves the standardizing of conditions of combustion for which no instruments were provided, and as no definite standard or aim was set before them, the scheme was soon abandoned.

B. A high percentage of CO_2 in the flue gas was adopted as a task basis for firemen in several plants, but the men were not trained, nor were they even shown how to obtain it. When they occasionally attained the mark, the question remained undecided whether high percentage of carbon dioxide was coincident with the most economical steam generation or not, and the method proved generally unsatisfactory.

C. A high percentage of CO_2 and low percentage of combustible in the ashes were factors upon which another attempt was made to specify more definitely the fireman's task. The question remains, however, whether the conditions which the fireman must observe to attain the task and produce gas rich in carbon dioxide, and an ash with little carbon, are actually the best for transmitting the heat of the gases to the water and steam, and whether at any load the same standard is equally beneficial.

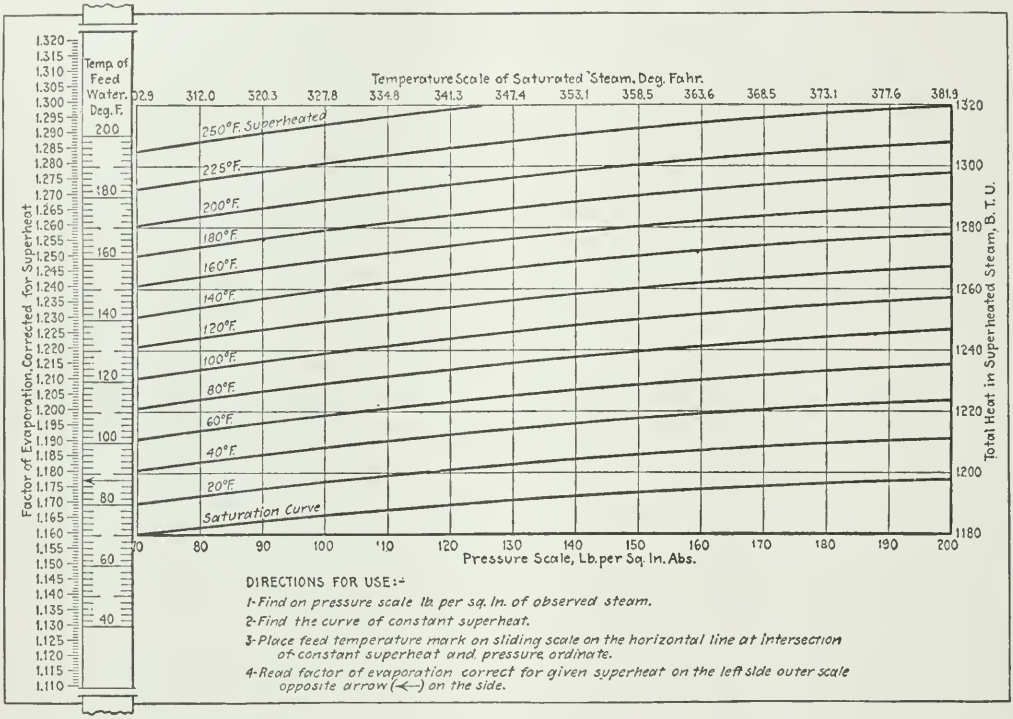

Temp of Feed Water, Deg. F.
Temperature Scale of Saturated Steam, Deg. Fahr.
250°F. Superheated
225°F.
200°F.
180°F.
160°F.
140°F.
120°F.
100°F.
80°F.
60°F.
40°F.
20°F.
Saturation Curve
Factor of Evaporation, Corrected for Superheat
Total Heat in Superheated Steam, B. T. U.
Pressure Scale, Lb. per Sq. In. Abs.
DIRECTIONS FOR USE:-
1-Find on pressure scale lb. per sq. in. of observed steam.
2-Find the curve of constant superheat.
3-Place feed temperature mark on sliding scale on the horizontal line at intersection of constant superheat and pressure ordinate.
4-Read factor of evaporation correct for given superheat on the left side outer scale opposite arrow (←) on the side.

FIG. 2. SLIDE RULE USED FOR DETERMINATION OF FACTORS OF CORRECTION

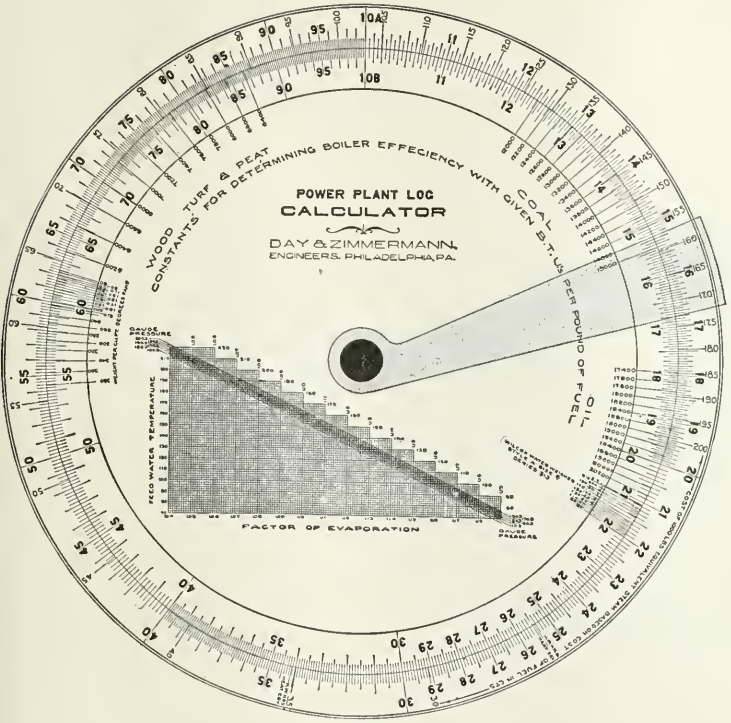


FIG. 3. POWER-PLANT LOG CALCULATOR

D. A limit on coal consumption as a task for railroad firemen was favored at one time. This idea, probably the most ridiculous and illogical, soon demonstrated its own weakness, and has been almost entirely abandoned.

The measurement of the extent of task accomplishment can be approached from either end, but it is more convenient to figure out the result, and, if this is below the standard, to turn to the record of conditions and there locate the cause of the discrepancy between the required results and those obtained. A gage for the measurement of the degree of fullfilment of task conditions is offered by the thermal efficiency of grate, furnace and boiler corrected for factors beyond the fireman's control.

Actually to calculate the efficiency of the boiler, furnace and grate is a tedious procedure, and is never done in power plants for a day, shift, fireman or gang of firemen working in teams. The simple method worked out by the author for use at the Warrior Ridge station requires the following data:

Coal records from store issue tickets and coal passers' reports compiled every eight hours.

Heat value of fuel determined by bomb calorimeter and value of coal in B.t.u. known for each coal pocket.

Amount of water fed to boiler (banked boilers fed separately) ascertained for same period.

Temperature of feed water.

Steam pressure.

Degrees of superheat.

These data are turned over to the station clerk who, from the slide rule shown in Fig. 2, ascertains the factor of evaporation on the basis of absolute boiler pressure, temperature of feed and of superheat, and by means of the power-plant log calculator, Fig. 3, he determines: the actual evaporation ratio; the factor of evaporation; the efficiency of steam generation; the equivalent evaporation; the cost of fuel per 1000 lb. of steam; all per watch or per man. The results of these computations are entered upon the daily-report form, Fig. 4. The whole procedure takes on the average 18 min. of the clerk's time.

Every case of failure on the part of any fireman to secure on his watch the combined boiler, furnace and grate efficiency of 70 per cent. or above, is immediately investigated by studies of other records and recording charts of drafts, temperature of escaping gases, nature of boiler refuse, etc., and if no reason can be found there, an examination of the physical condition of the equipment and apparatus is made. The result of this investigation is recorded on a form for cause of lost bonus, Fig. 5. This method is particularly valuable and, outside of its direct advantages, provides an additional and continuous training of the men in careful observation of harmful factors of the slightest nature.

Every fireman is given a daily bonus slip, Fig. 6, by which he is informed as to the results of his work before

DAILY POWER PLANT REPORT

PENN CENTRAL LIGHT AND POWER CO.
STATION Warrior Ridge

FOR 24 HOURS ENDING 9 | 14 | '13 | 7 A.M.

BOILER ROOM	WATCH 1	WATCH 2	WATCH 3	ENGINE ROOM	WATCH A	WATCH B	WATCH C
COAL USED (Including Kindling)	48800	49200	34000	HYDRO ELECTRIC OUTPUT	980	850	30
WATER EVAPORATED	419800	408200	284000	STEAM GENERATED OUTPUT	21220	20450	15070
ACTUAL EVAPORATION	8.62	8.32	8.37	LOAD FACTOR	79.5	64.4	67.5
FACTOR OF EVAPORATION	1.2187	1.2185	1.2287	STEAM PER KWH	19.78	20.00	18.85
EQUIVALENT EVAPORATION	10.50	10.13	10.28	COAL PER KWH	2.30	2.40	2.26
EFFICIENCY OF GENERATION	73.4%	70.8%	71.8%	THERMAL EFF-CY. OF PLANT	10.71	10.27	10.73
COST OF FUEL PER 1000 LBS. OF STEAM	0.0815	0.0845	0.0833	COST OF FUEL PER KWH (Including Coal Oil)	0.00201	0.00204	0.00200

REMARKS:

COAL USED FOR BANKING 1 BOILERS DURING 6 HRS. 55 MIN. 3000 LBS. COAL ANALYSIS BTU AVE 8.T.U. 13900

TOTAL OUTPUT _____ KW HRS. S. D. Port SIGNED

FIG. 4. DAILY REPORT FROM THE PLANT, SHOWING AVERAGE RESULTS

coming back to the next watch and, moreover, while he is proceeding with his work, he has, in addition to the previously mentioned instruments indicating the condition of firing, continuous information as to results that are being attained up to any moment of his watch. This is accomplished by having the coal weighing and water metering so balanced, that an even number of dumps of feed water and dumps of coal indicates that the ratio of evaporation is on the safe side of the requirements.

9 (MONTH) 6 (DAY) 10/3 (YEAR)

I HAVE INVESTIGATED AND REPORT BELOW THE CAUSE OF LOST BONUS

DEPT. Electr.

DISTR. War. Ridge

BY O. Hawn ON JOB Firing

CONDITION Draft was set wrong

Due to leak in draft gauge

RESPONSIBILITY IS ALLOCATED TO Maintenance Man

REMEDY ATTENDED TO BY ME (GIVE DETAILS FOR OTHERWISE) Ordering Repair

S. D. Port (SIGNED)

FIG. 5. RECORD OF CAUSE OF LOST BONUS

The record of attainment of the tasks by firemen devised by H. L. Gantt, and shown in Fig. 7, was adopted for general use by the above mentioned public-utility company. The illustration of this record kept from the start of task work at the Warrior Ridge station shows steady improvement and better habits of the men. While the May record shows only 68.7 per cent. efficiency of boiler and grates for the whole plant, the last month on the record showed an efficiency of 73.1 per cent. The number of day men falling short on the task is steadily decreasing. The number of men absent is chiefly due to days off and summer vacations, for the men work seven days a week. The departure from the principle of separate man's record made by the writer at first involuntarily, proved to be so gratifying, creating as it did a strong spirit of team work, that he has never attempted to split the record of two or three men working jointly firing one battery of boilers.

It will be understood that the men are paid a regular day's wage. In addition, those who accomplish the task which has been set them, in this case, the maintenance of a combined boiler, furnace and grate efficiency of 70 per cent. are paid a bonus. The maximum bonus would be equal to the amount of net saving accomplished under given circumstances, while the minimum bonus is, of course, equal to zero. When the bonus to be paid actually reaches either of these limits, it will lose its usefulness since it loses its stimulating effect, with the management, if the maximum, and with the men, if the minimum. Since in a average boiler house, the task results in about 25 per cent. saving on the coal bill, while the firemen's payroll is from 10 to 15 per cent. of the coal bill, it is evident that there is a considerable latitude for the adjustment of bonus.

In a boiler house, the amount of work per man per hour is constant and cannot be increased without knocking down the efficiency to a ridiculously low figure, but the number of foot-pounds of work can be reduced in an inverse ratio to the increase of efficiency, so that the question of preservation of a man's health, etc., eliminates any consideration of overspeeding. The conditions which were named for consideration are temperature of the room, ventilation, lighting, drinking water, restful seats and sanitary washrooms.

One familiar with the common layout of a power plant cannot overemphasize the importance of the above conditions to enable the men to live up to their tasks day in and day out. While engine rooms not infrequently offer very pleasant and sanitary surroundings, boiler houses, the most important part of any plant, are so built as to make them unbearably cold in winter and uncomfortably hot during the summer. Ventilation apparently serves either to fill the lungs with coal dust or to chill the perspiring men after cleaning their fires. Lighting is an unusual luxury, so that, after looking into the furnace, no man can read his gages or examine anything about the boiler. Good drinking water is rarely provided and restful seats with backs (seats without backs are equal to no seats at all) were never found by the writer in any boiler house; yet the mere fact that the firemen, if provided with seats having backs, can get through the cleaning of fires in 18 min. per 100 sq.ft., while without them, they consume at best 24 min., apparently should convince any unbiased mind.

Finally, the time element in relation to task setting for men, particularly, if the work requires a considerable strain, must be settled by examination no less careful than the study of the time rate of driving boilers. When, however, as in the case of firemen, both physical strain and attention are required, it was found that with strong,

FORM 8A8B1A

CHARGE

DAILY BONUS SLIP

DATE September

NAME J. Dearing NO.

DISTRICT - PLANT Warrior Ridge

HOURS DAY WORK	4
HOURS BONUS WORK	4
HOURS BONUS EARNED	1
TOTAL HOURS FOR DAY	9

REMARKS 71.8% - 4 hrs. firing on 3rd shift, 4 hrs. passing coal for sick coal passer.

SIGNED S. D. Port

FIG. 6. DAILY BONUS STATEMENT TO FIREMEN

healthy individuals the limiting fact or number of hours of profitable work is set, not by physical exhaustion but by weariness of spirit. Other conditions being equal, a fireman on a 12-hr. watch is found to be about 4.5 per cent. less efficient than the same man on an 8-hr. shift.

This time-limiting factor on human efficiency, taken in conjunction with a scientific certainty in determination of the most advantageous thermal efficiency, forms the ground on which the author rejected the sliding scale of

bonus based on results exceeding the task set by various degrees. The task set must be so little below the most advantageous point, that it could be reached with greatest benefit to all concerned, and it is not desirable either to fall short of or to considerably over-reach it. Offering extra compensation for excess of the task requirements means, in the final analysis, either that the investigator has not correctly determined both limits or that the management tempts a man to do more than the average employer dares to ask directly.

Discussion

William Kent criticized the method of presentation and the mathematics of the paper, and took particular exception to a diagram purporting to show the relation between efficiency and rate of driving for boilers of different types. One type of boiler is as efficient as another if properly set and operated. The owner had tried to go too far in his mathematical analysis and had not gotten anywhere.

D. S. Jacobus, of the Babcock & Wilcox Co., said that frequently after getting up the efficiency of a plant to a high figure he had endeavored to get the management to introduce some sort of a bonus system. He had not, however, attempted, and did not believe it possible, to get up a system where the men will individually be paid bonuses. The whole organization of the boiler room must be taken together, and he did not believe that one could differentiate between the men in any other way than to get the right sort of firemen and to get rid of the men who were poor. In a station where bonuses are paid, the men soon find out that the man who carries his fire the most uniform and steady is the one who gets the best efficiency. The poor fellows who are working hard and trimming their fires and making the steam, because they do not know the methods employed by the other men, are penalized, and will fall back, and the result is that there will be a feeling between the men, and they will work against each other.

Of two plants one may run comparatively steady and the other carry a swinging load. The plant which is running steady will have a much higher output than the other, and the firemen who have a swinging load will apparently be less efficient, while the firemen who have the steady load will have a higher efficiency. It is hard to cover that point with a bonus system. The other way of handling the situation is to put the right sort of a man in charge of the boiler room and make him responsible for getting the right kind of a result.

He did not believe that the general idea that the firemen are always against any improvement is correct. He had had considerable experience with going into fire rooms and getting the best out of the men. If the men once see that you are with them they will be with you. No one can go into a boiler room and present a lot of half-baked ideas and expect the firemen to follow them and

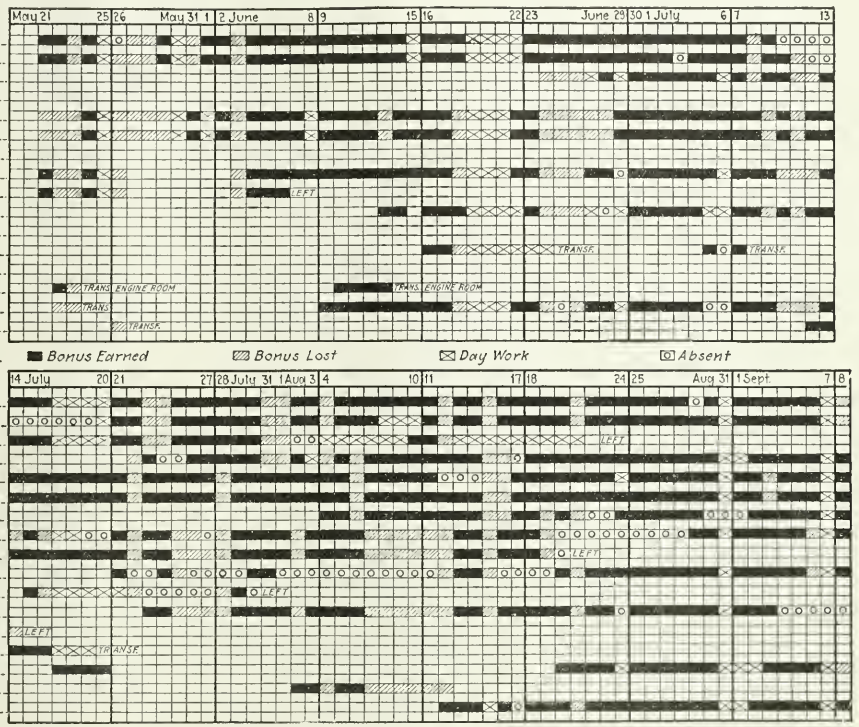


Fig. 7. Graphical Bonus Record

jumped on for something which may not work right. go in and the firemen feel and know in a certain nse that you are one of them, you can get the men to do vhat you want. It is seldom that one can apply the bonus method satisfactorily, but you can put a live man n charge and give the men some increase in pay in proportion to the amount that they can save by really exerting themselves to the utmost. He agreed with Mr. Kent that the author's method of getting at what a boiler should do is quite incomplete. For example, as far as he could see, there was nothing to connect the baffle arrangement in the particular boiler with the efficiency; but by changing the baffles in a particular boiler you can alter the heat transmission 50 to 100 per cent.

H. G. Stott, of the Interborough Rapid Transit Co. of New York, also took issue with the curve which purported to show the most economic loading for various types of boilers. His experience is that the type of boiler has very little to do with the question. It is entirely a question of the furnace, the combustion of the fuel, and one can perfectly easily drive a boiler up to 400 per cent. of the rating or even more. The point as to whether the tubes are arranged in one direction or another is immaterial. In the table, the fire-tube boiler with superheater is given as the most economical one. He did not think this was quite so. He had had efficiencies on the regular Babcock & Wilcox boiler equal to those shown in the curve, and this boiler can be carried to practically an unlimited rating. It must not be forgotten that there is mixed up with this question another, which it is absolutely impossible to separate from the consideration of the matter, and that is the economics of the plant. The efficiency may be run down during the peak load to 60 per cent., and yet the operation be more economical when the fixed charges are taken into consideration than when the plant is running at 80 per cent. When running at 80 per cent., the boilers must be run at about 70 per cent. of the so called rating, and if the fixed charges and the operating charges are plotted, it will be found that their sum is relatively unimportant for the two or four hours a day during which the peak load exists. The important thing is to take the fixed charges into account and to keep down the number of boilers on the line and also the number of banked boilers.

He is thoroughly in favor of educating the firemen, but from a different point of view. He believes that with modern equipment in the boiler room we should no longer have firemen at all but combustion engineers. The time has gone by when we are going to take an illiterate man and train him to be an expert in combustion. We do not think of doing this in our construction or engineering work. On that work we employ men who have graduated from technical schools. He presumed that we cannot get that type of man to go into the boiler room yet; but the time is coming when we will be willing to pay more to the man who operates the boiler than to the man who operates the turbine room or the engine room, because one can make no change in the economy of a plant and the other can make from 5 to 10 per cent. difference; so that he looks for the time when we can completely equip a boiler plant with modern combustion appliances, with stokers which are practically automatic and require little attention, and then we must have engineers and not firemen at all in the boiler room.

R. J. S. Pigott, of Columbia University, also directed attention to the diagram purporting to show the economic loading for different types of boilers. He said that there is still a good deal of misapprehension among engineers as to the economic point of loading, either of the boiler or a turbine. The efficiency of the boiler and of the turbine has much the same characteristic; namely, there is a dome or high point at some place in the load. With the turbine it is usually at full load that the best efficiency occurs. Beyond this point there may be some 25 or 50 per cent. capacity allowed for overload. The best loading occurs very low in the total capacity of the boiler, somewhere about one-third or one-quarter of the maximum capacity. The total rating of the engine room consists not only of the usual rating of the turbine but must include that of the auxiliaries necessary to run the turbine. In other words, the steam rate of the turbine may be 12 or 13 lb. per kw.-hr. at its best load, but when we superimpose on that the steam required to drive the auxiliaries, the water rate is much higher, and the best water rate, including the auxiliaries, is at a higher load always.

This is also true of the boiler room. The auxiliaries required to drive the pumps, forced-draft fans and possibly induced-draft fans, boiler-feed pumps, etc., must be taken into account. While the condenser auxiliaries run with a practically constant amount of steam, no matter what the load on the turbine is, the units of the boiler room are different, and require somewhat less steam at lighter loads than at full load. The total steam consumption of a centrifugal boiler-feed pump, for instance, at zero delivery, is seldom less than 50 per cent. of the steam at full load on the pumps. If the steam required for the auxiliaries is subtracted from the total steam delivered by the boilers, and the result divided by the boiler horsepower, it is usually found that the net efficiency of the boiler room is at a much higher load on each boiler and is not at the best load on the boiler itself.

Edward A. Uehling, of the Uehling Instrument Co., said that one thing that this and Mr. Parker's paper upon the Delray boilers had brought out very fully, was that in order to obtain boiler efficiency the boilers must be tested by experts and put into proper condition for getting high efficiency. Next and just as important is the fact that means must be furnished to the boiler room, the fireman, or whoever is in charge, to maintain the efficiency that has been attained. This cannot be done by simply making a test once in a while: it must be done continuously.

There may be and doubtless are numerous methods by which control over the firemen and control over the efficiency of the boilers can be maintained. One way is to measure the water that goes in with the coal and the steam flow. Correlate these items and you know what the fireman has done. Another way is to control the combustion, the rate of driving the furnace, and also the heat which is wasted up the chimney. Either of these methods will suffice to obtain the proper regulation. The question is, which is the better, which is the cheaper in installation. For the last a CO_2 instrument is necessary. We have heard considerable about the difficulty of keeping these instruments in operation. There is less difficulty in keeping the CO_2 recorder in operation than in keeping a pump in operation. The situation is this: The man who is in charge of the pump is discharged if he

does not keep it running properly. There is nobody in responsible charge of the CO_2 instrument, and if it is out of order today they say, "We will fix it tomorrow," and that is why it is not always kept up to the mark.

There are installations where they have 20 units, each fitted with a pyrometer and a CO_2 recorder, which instruments are kept in perfect order by an illiterate Italian. He may not understand all about the scientific principles of the instruments but he knows just what to do. The water level has to be kept up, the clock has to be wound, and the absorbing reagents to be changed. When that is done properly, and the filters are taken care of, that is all there is to it.

As to the capacity of a boiler, Doctor Jacobus referred to the fact that the fireman gets onto the fact that if he fires easily, he can get a high CO_2 and, consequently, get the bonus, and the poor devil who is making the steam does all the work and gets nothing. Therefore, it is necessary to know the rate of driving, and when the rate of driving is known and the CO_2 is known, and the stack temperature is known, you can give individual bonuses, and that is the only way in which you can select the best firemen. You can tell then whether each fireman is doing what he ought to do.

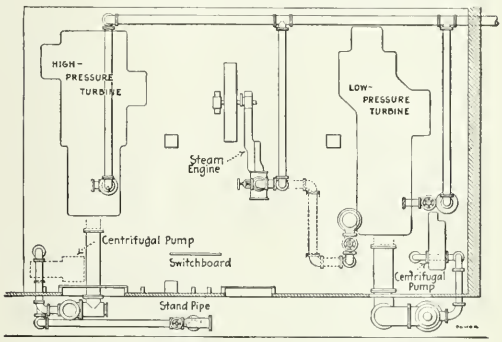
Low-Pressure Turbine in Veneer Mill

The Astoria Veneer Mill & Dock Co., of Steinway, L. I., is doing a large business in hardwood veneer and lumber. Naturally, a great deal of power is required to handle the logs and in the various processes of manufacture. Some of this power is supplied direct by engines in the individual mills and some by motors taking current from a central plant. There are, of course, numerous hoisting engines and steam feeds for the carriages of the sawmills, and at times as much as 500 hp. in boiler capacity is required for steaming the logs, previous to trimming off the veneer.

To supply this steam, the plant is equipped with four Parker water-tube boilers aggregating 1500 hp. There is one 500-hp. unit, two 350-hp. boilers and one of 300-hp. capacity. The fuel is sawdust and chips. The quantity of coal required is usually small, but, of course, varies with the supply of refuse. All the slabs and edgings from the sawmill are ground up in a mill hog and turned into the conveyor which carries the sawdust, so that by the time the material reaches the boiler room, the fuel is thoroughly mixed.

In the veneer-cutting room, there are two 250-hp. simple engines, one of Skinner make and the other an Erie. These engines are belted to line shafts and their exhaust is used for heating and drying purposes. In the cedar mill, which turns out cigar-box lumber, there is a 50-hp. Erie engine, which is belted direct to a rotary cutting machine. Excluding the numerous hoists and steam feeds, previously mentioned, the balance of the power is supplied from the central plant. Here is a 350-hp. Clark Bros. 20x24-in. simple engine, which is belted to line shafting supplying power to the sawmill. There is also a high-pressure 300-hp. De Laval turbine driving two 200-kw. Crocker-Wheeler generators delivering two-phase current at 440 volts. This machine supplies a large number of motors varying in capacity from 3 to 140 hp. Naturally all of these motors are two-phase and are distributed throughout the various mills. The turbine exhausts into an old-style, single-jet Schutte & Koerting eductor condenser equipped with a standpipe. With 700 gal. of water per min., the condenser is capable of holding a vacuum of 27 in. A 15-hp. Chandler & Taylor engine belted to a Hobart direct-current generator supplies the lighting. The power engine and this unit have been run noncondensing.

With the installation of a new sawmill, more power was required, and, to obtain this power with little or no additional steam, a mixed-pressure turbine was installed by the Turbine Equipment Co., of New York City. This turbine is also a De Laval rated at 200 kw., which it is designed to give on a pressure ranging between 2 lb. gage and atmospheric. The turbine drives two 100-kw., two-phase Allis-Chalmers generators at a speed of 900 r.p.m. The turbine is equipped with two sets of nozzles, one for high-pressure and the other for low-pressure steam, either of which may be used as conditions demand. From all indications, however, there will be plenty of exhaust steam, the main source being the 350-hp. engine driving the older sawmill. A connection into the exhaust main supplying the turbine from a turbine-driven pump has already been made, and it is the intention to make other connections so that the exhaust from the lighting unit and perhaps from the steam feeds of the sawmill may be used.



Layout of Central Plant in Veneer Mill

Naturally, the mixed-pressure unit is operated condensing, a vacuum of 28 in. being obtained by a Schutte & Koerting multi-jet eductor condenser equipped with a vacuum breaker. In this installation there is no standpipe, and the water is delivered direct from the pump into the condenser. The mixed-pressure turbine has been in operation for a number of weeks and has been operated in parallel with the high-pressure turbine, although favorable conditions are required for this method of operation. In case of an emergency, Edison breakdown current is available.

As the fuel has been largely waste from the plant, no records have been kept. Previous to the installation of the new sawmill, the amount of this refuse was just about sufficient to fulfill the demands, and any additional power would have required the use of considerable coal under the boilers. With the present arrangement no more fuel is required and enough exhaust steam is available to supply the new unit, so that the additional 200 kw. is supplied practically for nothing, excluding, of course, interest and depreciation on the investment.

ELECTRICAL DEPARTMENT

Long-Distance Water-Level Indicator

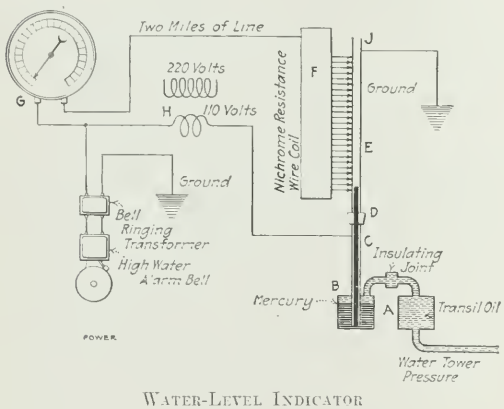
By A. V. Youens

The municipal water-works and power plant at Palo Alto, Calif., is located about two miles from the reinforced-concrete water-tower storage which floats on the water-distributing system.

This tower is of cylindrical form, 76 ft. high and 35 ft. in diameter. The lower part of the tower is an open room for use as an auxiliary pumping station while the upper section forms a water storage of 155,000 gal. capacity. The roof of the pumping-station room is of dome shape and forms the bottom of the water reservoir. The roof of the tower is also slightly dome shape and is of reinforced concrete. Iron steps that were built in during the construction lead to the top of the outside wall of the tower.

As it is not a particularly desirable job to climb to the top of this wall for general inspections there were objections to the regular float type of water-level indicator. A device near the ground was much to be preferred.

Experiments were made with a mercury column, balanced against the water-tower pressure, having a float in the mercury by means of which, through a cord, we intended to actuate a sliding contact. The float in mercury was not a success as its response to changing of mercury level was not sensitive or reliable. The float idea was dropped but the mercury column was retained and has worked out successfully in the water-level indicator described below.



Water-Level Indicator

Referring to the illustration, the bottom of chamber *A* is connected by ¼-in. iron pipe to the bottom of the concrete water tower. Chambers *A* and *B*, both made of iron fittings, are interconnected by short iron pipe in which an insulating joint is inserted. A ¼-in. iron pipe *C* having running threads at the lower end is close to the bottom of the chamber *B* and a reducer *D* into the top and larger end of which is screwed a hard-rubber tube *E*, the bore of which is practically the same as the ¼-in. pipe, is provided. Properly spaced and entering through the wall of this rubber tube are 25 iron machine screws which correspond to a 25-ft. working range of water level in the concrete tower. Each screw is permanently connected by a flexible copper wire to a predetermined point of the resistance coil on the wooden drum *F*. The lowest or No. 1 screw connects to one extreme end of the resistance coil while the other end is connected to one side of a galvanized-iron line leading to the water-works two miles distant, and after going through the water-level instrument *G* the electrical circuit is completed through the 110-volt secondary of the transformer and finally connects to the ¼-in. pipe *C*.

Chamber *A* and its connecting pipe to chamber *B* are filled with transil oil which is, of course, a good insulator of electricity. As already stated there is an insulating joint in the short pipe connecting chambers *A* and *B*. Therefore, the pressure pipe to the tower, together with the water column it contains, is insulated electrically from chamber *B*.

Chamber *B* contains mercury and this mercury rises up columns *C* and *E* corresponding to the pressure exerted on top of the mercury, which pressure is due to water level in the tower.

The small transformer *H* is energized from the regular municipal lighting primaries and located approximately at the center of distribution. The primary voltage is controlled by an induction-feeder regulator at the power plant, and, therefore, the secondary voltage serving the water-level indicator is fairly constant.

The water-level instrument, located on the switchboard at the water-works and power plant, is a long-scale voltmeter, the face of which we removed and substituted one having an evenly divided scale of 25 block divisions. Each block division is a little over ½ in. of scale. Therefore, the instrument pointer can swing within a range of ½ in. and still be on the same block corresponding to a certain foot depth of water in the tower. With this arrangement of scale and pointer swing a corresponding voltage variation is allowable without affecting the accuracy of the water-level indicator equipment.

The proper spacing of the 25 screws in our particular case was calculated in the following way (not taking account of the negligible correction for difference in relative weights of transil oil and water):

Let

M = Area, in square inches, corresponding to diameter of mercury chamber *B*;

N = Area, in square inches, corresponding to bore of pipe *C* or rubber tube *E*;

X = Lowering, in inches, of mercury level in chamber *B* corresponding to one foot rise in water level in the tower;

Y = Rise, in inches, of mercury in rubber tube *E* corresponding to lowering X in chamber *B*.

Then

$$M\ X = N\ Y$$

In our particular case

$M = 14.75$ *sq.in.* and $N = 0.104$ *sq.in.*

Substituting values for M and N we have:

$$14.75\ X = 0.104\ Y$$

$$X = \frac{0.104\ Y}{14.75}$$

also,

$X + Y = 0.883$ *in.* (1 *ft. water* = 0.883 *in. mercury*)

therefore,

$$\frac{0.104\ Y}{14.75} + Y = 0.883$$

or

$$0.007\ Y + Y = 0.883$$

Then,

$$Y = \frac{0.883}{1.007} = 0.877\ in.$$

for each foot of difference of water level in tower.

Or the spacing of screws might be determined by trial. Having the location of top-contact screw No. 25 established, the water in the tower could be allowed to lower 25 ft. and the corresponding level of mercury in the rubber tube E noted, which would give the location of the contact screw No. 1. The distance between these two points would represent the total working range of mercury column. Then with a pair of dividers the intermediate-contact screw locations could be laid off.

The permanent height of the top screw No. 25 with reference to chamber B was established by filling the concrete tower to the desired high-water level and then lowering an insulated wire down the ¼-in. pipe C (previous to cutting C off to add the rubber tube E) until the exposed end of the wire touched the top of the mercury column and closed the buzzer circuit-testing set. Then the iron pipe C was cut off and threaded so that when the rubber tube E was screwed in place the top-contact screw was located at the right height.

The resistance coil on the drum F was made as follows:

A wooden cylinder was turned out in a lathe and a V-thread of ten to the inch cut along its length. In fact, the cylinder was of soft wood and the thread was pressed in by a wheel cutter taken from ordinary three-wheel pipe cutter and held in the tool post of the lathe carriage. Then No. 28 Nichrome resistance wire was guided over the tool post into the thread on the cylinder as the carriage traveled back along the lathe bed with the same lathe gears in as were used in cutting the threaded groove. This afforded a very simple and convenient method of winding the resistance wire in very close turns so that the maximum length of wire could be put into a minimum space.

The 25 permanent points of connection were then located in the following way:

The two ends of the two miles of line wires were temporarily joined together at the water-tower end of the line, leaving the mercury tube out of consideration for the time being. A series circuit was then made up of the two miles of line, 110-volt secondary winding of the transformer, water-level instrument and enough of resistance coil on the drum F to swing the instrument needle to the middle of the scale division 1. This gave the location of the lowest point No. 1 on the resistance coil and connection was made by fastening with small blind staples the bared end of a piece of single lamp cord in the threaded groove of the drum against the bare resistance wire. The loose end of this flexible cord was then attached to the short length of the bare wire (serving temporarily in place of mercury column).

The one end of a second piece of flexible cord was fastened to the wire serving as a mercury column and then, by trial, touching the other end of the cord at points along the resistance coil, above location No. 1, we located a point No. 2 that raised the instrument pointer to the middle of the scale division 2. In like manner all the 25 points on the resistance coil were determined, one by one, in consecutive order. With all 25 flexible cords connected, forming parallel circuits between the resistance coil and wire serving as a mercury column, the instrument needle indicated 25 on the scale corresponding to 25 ft. of water in the tower.

The resistance drum F was then taken to the water tower and mounted vertically opposite the rubber tube E. The 25 screws in the rubber tube were then connected to corresponding flexible leads from the resistance coil, after first removing the short length of wire which had served temporarily in place of the mercury column.

Finally one side of the tower end of the two-mile line was attached to the upper end of the resistance coil and the other end fastened to the ¼-in. pipe below the rubber tube.

From the above description and reference to the illustration the action of the water-level indicator will be readily understood. With a very low water level in the tower the top of the mercury column may be below the bottom screw No. 1 of the rubber tube E in which case the electrical circuit would be open and the water-level instrument at the water-works would indicate zero. Then as the water level rises, the pressure in the mercury chamber B increases, which raises the mercury column until it reaches the contact screw No. 1 when the instrument at the water-works shows 1 ft., and so on up and down the working range.

The object of the insulating provisions, as already described, was to afford a ground-return circuit for ringing a high-water alarm bell. The alarm circuit is made up of this ground return and part of the water-level indicator circuit which takes in the transformer secondary and mercury column.

The extreme top screw J is located at a point in the rubber tube E corresponding to the overflow of the water tower (or any high-water point desired). This screw is grounded. Also, at the water-works, one primary terminal of the bell-ringing transformer is grounded and the other attached to the side of the line that leads from the water-level instrument through the line transformer to the ¼-in. iron pipe C. Therefore, when the mercury column rises to the point J the bell-ringing circuit is closed through the ground and mercury column and the bell alarm is sounded. Of course, at this high-water alarm point the ground return would form a shunt path, practically cutting out current through the water-level instrument, thereby causing the pointer to drop toward zero. But this condition need cause no confusion because of the meaning of the high-water alarm. Upon closing down the pumps the water level in the tower would drop and as soon as the mercury column lowered sufficiently to break contact with the screw J conditions would at

once adjust themselves and the needle of the instrument would immediately rise to division 25 and remain there until water lowered or raised to next foot mark.

The above described water-level indicator was designed by the writer about three years ago. A glass tube with platinum contacts, which was kindly constructed for us by professors in the chemical department of Stanford University, was originally used instead of the present rubber tube. But for some unknown reason this tube was one day found cracked at one of the platinum contact leading-in wires. This may have been due to jar from the many trains on the very near-by railroad line or possibly from heat due to arcing at contact during operation or perhaps due to some inherent strain in the glass tube. The rubber has thus far given no trouble whatever.

Fire Hazard in Turbo-Generators*

By G. S. Lawler†

The chances of electric generators of the older types being seriously injured by fire in the event of some part of the insulation failing is slight. Occasionally arcing will ignite the insulation, but it is seldom that the fire will spread much before it is extinguished. This freedom from fire damage is due principally to the comparatively low speeds, the accessibility of the combustible insulation, and the fact that the machines being of large mass per unit capacity, the insulation is considerably distributed.

This condition is reversed in generators of the turbo type. The chief causes of the increased hazard are as follows:

The volume occupied by this type is much less for the same capacity than that of the older types so that the combustible insulation is more concentrated. Also the amount of combustible insulation on the higher-voltage generators is naturally greater than that in the low-voltage machines.

These generators being of large capacity in many instances, an enormous amount of energy is involved in a short-circuit, especially at the instant the short occurs and as the arc is confined in the limited space with the combustible insulation, it would seem impossible for the insulation to escape being set on fire at many points simultaneously.

The machines are cooled by forcing large quantities of air through the spaces between the conductors and the large and constantly renewed supply of oxygen will hasten combustion after it is once started.

The generators are totally incased with the exception of the air inlets and outlets and even these in some designs are under the machines. This construction prevents access to a fire and much valuable time will be consumed before extinguishing agents can be used effectively. When the field current is cut off, as is necessary in case of a short-circuit, the only means of bringing the rotor quickly to rest is lost and it will continue to run for a long time after the steam has been shut off. This continued rotation is not conducive to the quick extinguishing of a fire.

While the generators may be free from fires during the earlier portions of their lives owing to the proper use of reactances which prevent external troubles seriously affecting the machines, as they get older the ordinary causes of breakdown of insulation are likely to occur and fires result.

Undoubtedly the manufacturing companies have given serious thought to the reduction of the fire hazard in turbo-generators and have employed all means practical at the present time to this end, but there is still much to be desired. The following means would seem to minimize the chances of a serious fire:

(a) If a suitable material could be found, a noncombustible outer covering could be placed over the insulation on the stator end connections. This would greatly delay the spread of fire and even if no other protective means were taken, would undoubtedly prevent much serious damage.

(b) If a noncombustible outer covering should be put on, its advantages would be partially lost in time unless the cooling air were freed of the dirt and oily vapor liable to be in it. This could be done by filtering.

(c) Means could be provided for cutting off the air supply in case of fire in generators by placing dampers in the inlet ducts designed so as to be normally held open by fusible links.

(d) Arrangements could be provided for the quick introduction of carbon-dioxide gas into the machines. The carbon dioxide could be kept in liquid form and piped through valves, expansion tanks, etc., to the generators. The valves could be arranged to be opened by the closing of the air-inlet dampers, so that the gas would be automatically introduced into the generators.

The employment of some efficient method of reducing the fire hazard in generators of the turbo type either along the lines mentioned or in some other way is important. The value of these generators is great and the damage by fire may amount to a considerable proportion of the first cost. It is probable that the damage is more likely to occur toward the end of the life of the generators, but even then the loss may be large, both directly and indirectly. The large central stations have reserve units, so that the increased damage due to fire in one of their generators would probably not affect the continuity of the service, but the increased time necessary for repairs may be long and during this time the reserve capacity will be weakened. In the case of industrial plants the longer time needed for repairs might be serious. Many manufacturing concerns who generate their own current depend on only one unit and, therefore, their whole production, or a large part of it, would be affected.

*From paper read at annual meeting of the A. S. M. E.
†Electrical Engineer, Inspection Department, Association Mutual Fire Insurance Companies.

Electric Distribution at the Canal—During the year it was decided to install for the transmission line an overhead system of 44,000 volts, extending from Balboa to Cristobal, and connecting the Gatun hydro-electric power station with the present Miraflores steam-power station, so that they may be operated separately or in parallel, as necessary. Four substations are provided, and located at Cristobal, Gatun, Miraflores and Balboa. The complete line consists of duplicate three-phase lines, one of which is carried on each side of track-span bridges spaced 300 ft. apart on tangents and 200 ft. on curves along the whole length of the Panama R.R. The bridges are of structural steel, with a clear track span of 36 ft., and an overall height of 40 ft. The conductors are to be 2/0 stranded copper wire spaced with a clearance of 5 ft. They are supported from brackets outside of towers, with three-part suspension insulators, with noncorroding connecting links to allow a maximum life and a minimum of line troubles.—"Canal Record."

GAS POWER DEPARTMENT

The Large Gas Engine in Europe*

By Prof. P. Langer

The tendency to utilize in gas engines the enormous quantities of waste gases from blast furnaces had its inception in Germany about 20 years ago. The two-stroke-cycle system seemed suitable for large engines, but full success was not attained until about 11 years ago when the large gas engine was brought to a high state of perfection by the Maschinenfabrik Nuernberg in the form of the double-acting four-stroke-cycle type, with two cylinders in tandem.

Regulation of Large Gas Engines

The attempt to attain stratification of the mixture inside the cylinder has led to very complicated valve-gears. It was hoped that a gas valve which remained open during only a part of the suction stroke would direct the gas in such a manner that a combustible mixture would be present at the point of ignition even under the lightest loads, while the balance of the combustion space would be filled with inert air. The result, however, did not justify this hope.

Throttling of gas and air simultaneously, or in other words, regulation of the quantity of mixture only, is to be preferred to the throttling of gas only, as the former method is less sensitive and makes possible a more certain control by the governor. But even the simplest method of quantity regulation will give satisfaction only if the action of the governor upon the throttle valve has been given careful consideration. It is wrong to let the governor act in such a way that the valve opening is proportional to the travel of the governor sleeve, as the following consideration will show:

The result of throttling is to reduce the quantity of mixture drawn into the cylinder during each stroke. The volume of charge remains the same, as the cylinder is always completely filled, but its density becomes less, also its weight and the amount of energy supplied.

These relations are shown in Fig. 1. Starting with a certain velocity C, of the mixture through the valve, which is determined by the opening of the valve; the curve shows the velocity as a function of the position of the governor. This velocity can be produced only by a certain drop in pressure as the mixture passes to the cylinder, so that the law according to which the absolute pressure in the cylinder changes is also definitely determined. The shape of this curve shows that the lower part of the travel of the governor sleeve is almost without influence and that the total regulation is limited to the upper travel. This results in marked irregularity of the indicator diagrams, as the smallest motion of the governor causes considerable changes in the quantity of mixture supplied.

The remedy is found in changing the connection between the governor sleeve and the throttling mechanism, so that in the low positions of the governor the throttling action is more intensive than in the upper positions. This can be accomplished by off-setting the connecting link between the governor and the throttling valve.

Even the best scheme of regulation will not avail, if the proportion of mixture is not properly controlled. In engines that have separate pumps for air and gas, as is usual in two-stroke-cycle machines, where air and gas are furnished in measured quantities, it is comparatively easy to get the proper proportion, at least at full load. Difficulties are found, however, in four-stroke-cycle machines, where gas and air are drawn in by the working piston in parallel. In this case the proportion of mixture is not readily controlled, because the quantities drawn in depend not only on the free opening of the admission valve, but also on

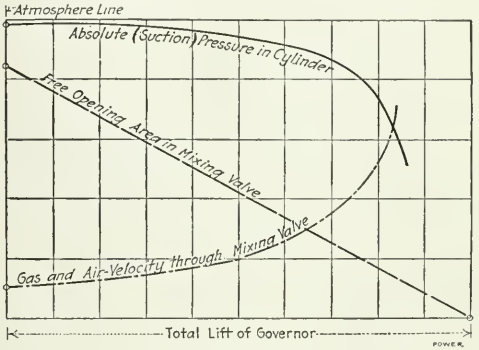

Atmosphere Line
Absolute (Suction) Pressure in Cylinder
Free Opening Area in Mixing Valve
Gas and Air-Velocity through Mixing Valve
Total Lift of Governor
POWER

Fig. 1. Illustrating Action of Governor on Throttle Valve

the product of this opening area and the velocity of flow through it. Incidental changes in pressure may influence this velocity strongly. The difference in specific gravity must be considered when deciding upon the proportion of the ports for correct mixture in engines that use gases lighter than air. Disregard of this leads to too rich mixtures and the engine becomes choked with gas. The many failures of engines working with coke-oven gas are partly explained by wrongly proportioned gas ports. The intake velocity in the mixing valve must be at least 1000 ft. per min. to avoid disturbing variations of the mixture due to accidental changes of the gas pressure. Velocities of about 1200 ft. per min. are considered normal. In order to avoid too intensive a throttling action and consequent reduction of power, the piping and other passages leading to the mixing valve must be proportioned liberally, so that the total drop in pressure is advantageously concentrated within the valve itself.

For a long time difficulties were experienced in driving variable-speed blowing engines by four-stroke-cycle gas engines. In most cases the gas arrives at the mixing valve under a pressure of several inches of water, while

*Presented at the annual meeting of the American Society of Mechanical Engineers.

he pressure of the air is somewhat less than atmospheric. Then the machine is run slower the suction action of the ston is reduced and the intake velocity of the air decreases more rapidly than that of the gas, until finally is reduced to such an extent that nothing but gas enters the cylinder. It is evident that, even before this

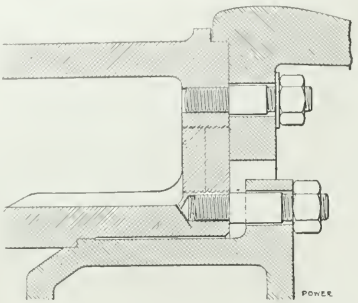


FIG. 2. ONE-PIECE CYLINDER, SHOWING COMMON LOCATION OF CRACK

point is reached, the engine will choke with gas and will stop. A governor which regulates the quality of the mixture would only favor this suffocation of the engine with gas. In such cases the conditions are improved by increasing throttling at normal speed.

CYLINDERS

Improvements in design as well as improvements in foundry practice have greatly reduced the breakage of cylinders. Views upon the most suitable shape still differ considerably, however. Some designers, after careful experiments, have abandoned the split-jacket cylinder in favor of the normal one-piece cylinder, while others have gone exactly opposite, and split not only the jacket, but also the inside cylinder. The one-piece cylinder is just as strong as the split one. The latter has come principally from the desire to avoid initial stresses in the direction of its axis, which put the inner cylinder under tension, because in casting it cools later than the rest of the casting. Besides, by casting the two halves separately, it was attempted to obtain as dense a wall as possible for the combustion chamber. Finally, splitting the cylinder has the advantage that customers who consider a cylinder after the proper construction can be satisfied, inasmuch as the insertion of liners in one-piece cylinders presents some difficulties.

Besides simplicity and the absence of the danger of leakage in the highly strained cylinder joint, the one-piece cylinder allows a better transmission of the forces from the cylinder to the frame. The fact that one-piece cylinders frequently broke at the place indicated in Fig. 2, caused an overestimation of the stresses in the casting. Closer investigation shows that the breaks are caused simply by making the part between the cylinder and flange too weak. The wall, besides being too weak originally, is further weakened by the large number of cover studs and the break is further induced by excessive tightening of these studs. This can be remedied by properly reinforcing the point of danger and by placing the joint on the outside.

While these breaks have their origin in the stresses set up by irregular cooling of the casting or by irregular heating in operation, cracks of an entirely different nature have been observed on the walls of the combustion chamber. These so called fire cracks always start in a place where the transmission of heat to the cooling water is impeded (see Fig. 3). In the smooth and homogeneous wall the differences in temperature of the different strata are small and the temperature of the wall is comparatively low, as long as accumulated scale or similar causes do not offer an obstacle to the transmission of heat. When, however, the rate of transmitting heat to the cooling water is reduced, there will be accumulation of heat, causing a rise in temperature during the expansion and exhaust strokes. The material will tend to expand according to the average temperature of the wall and it will be able to do this without resistance because it is under tension on account of the stress in the casting. In operation, therefore, the stress will be relieved. On account of temperature differences, however, in different strata of the wall, there will be stresses in the wall itself, compression in the hotter zones and tension in the cooler ones. As soon as cold mixture is admitted during the next suction stroke, the surface of the wall is cooled

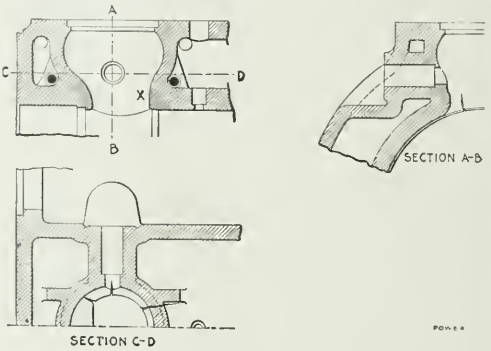


FIG. 3. SHOWING FIRE CRACKS

intensively, and the inside layers of the wall cannot follow rapidly enough to cause the establishment of settled conditions corresponding to this flow of heat.

The occurrence of a crack, which in the beginning is scarcely ⅛ in. deep, apparently relieves the stress to a certain extent and only the natural tendency of the cast material to continue to break, together with the external mechanical forces, causes the crack to open further. In most cases drilling and calking at the end of the crack will stop this. The timely discovery of the crack is, however, rather difficult, as it is not open after the wall is uniformly cooled.

The first step in combatting the occurrence of these cracks is to reduce their real source, that is, the differences in temperature, to an amount that is harmless. As the sudden changes of temperature are caused by the very nature of the gas-engine cycle, these attempts must be confined to avoiding all irregular ignition and slow combustion. Furthermore, it is necessary to make the conductivity of the wall uniform in order to avoid all accumulations of foreign material.

The commonly used globe or onion-shaped passages for inlet and exhaust valves are therefore not suitable, and lately the form shown in Fig. 4 has been preferred.

Cast steel is not a suitable material for gas-engine cylinders. The larger expansion due to heat as compared with cast iron and the very much higher modulus of elasticity causes increased stresses, while the strength of cast steel is not proportionately greater.

Increasing Output of Large Engines

The principal task upon which the gas engineer is laboring, besides that of enhancing the reliability of the machine, is that of making it cheaper, partly by simplifying its construction and partly by increasing its output. At present it can hardly be imagined that the gas engine can be made cheaper by making its construction simpler, now that the complicated valve-gears have disappeared. Reduction of weight is not to be recommended. Until recently experience has demanded a continuous increase of engine weights. Economy in material would reduce reliability and the life of the machine.

Somewhat better prospects appear in the attempt to reduce the cost by increasing the output of the machine of a given size. Increasing the speed is not practicable, at least not with such as blast-furnaces gases. The reliability of the machines would be lessened, not even considering the fact that the time available for the combustion of the mixture is too short and that, therefore, the losses on account of incomplete combustion would become too large. A comparison of the results of operation of gas-operated blowing engines, which run relatively slow, and engines driving dynamos, proves that the former require considerably less repairs than the latter.

The heat value of the mixture is also determined by the minimum excess of air necessary for complete combustion, and there remain only the two factors of volumetric and total efficiency. It is conceivable that the total efficiency might be increased by increasing the thermal efficiency of the process. This, however, is dependent upon increase of pressure and for this reason such a possibility must be eliminated. The volumetric efficiency can be increased in two ways; by cooling the charge and by increasing the pressure of the charge. The first method was proposed some time ago but has not been adopted because in most cases the cooling water is warmer than the atmosphere and the incoming gas. Besides, a large gain cannot be expected, as decreasing the temperature 10 deg. could only increase the output about 2 per cent.

The other method for increasing the output, which lately has attracted renewed interest, consists in increasing the pressure of the charge and simultaneous scavenging of the exhaust gases. In this manner a given suction volume of an engine can accommodate a larger weight of charge and greater output can be attained.

The original purpose of this method, which has been known in England for many years, was the avoidance of preignition by scavenging the cylinder of what remained of the hot exhaust gases. It is the competition into which the gas engine has lately had to enter with the steam turbine that has brought to the front the possibility of increased power output and lower cost.

The simplest method of realizing the scheme of scavenging and charging consists in closing the exhaust valve late and opening the inlet valve early. The time during which both valves are open is used for scavenging. To avoid loss of gas, the latter is admitted only after the exhaust valve is closed. At the end of the suction stroke the mixing chamber must be cleansed of combustible mixture by scavenging with pure air, as otherwise backfires would occur at the beginning of the next scavenging period. Gas and air are brought to the machine under a pressure of about 3 lb. per sq.in. gage. On account of this increased pressure the weight of the charge is about 20 per cent. greater than that of the normal method. Scavenging the combustion chamber also furnishes further space for fresh mixture. Experiments have shown a mean effective pressure of about 100 lb. per sq.in. In continuous operation mean effective pressure of 85 lb. per sq.in. can be reached.

In spite of the lower compression the heat consumption per unit of power is not increased. This is explained first by better combustion of the charge which is not contaminated by the remains of the exhaust gases, and secondly by a decreased percentage of loss in the cooling water. The increased temperature of the cylinder walls has caused objections against continued operation with scavenging and forced charge, and some justification cannot be denied to these objections.

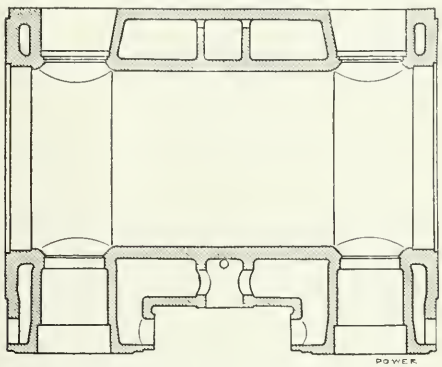


Fig. 4. One-Piece Gas-Engine Cylinder That Avoids Globe-Shaped Passages to Valves

Improving Gas-Engine Economy

The desire of gas-engine builders to improve the economy of the gas engine, has lately brought to the front interest in the utilization of waste heat. The high temperature of the exhaust, about 880 deg. F., makes possible its use for the generation of steam in boilers, which have to be placed as closely as possible to the exhaust chamber. As a matter of fact, it is possible to obtain 2 lb. of high-pressure steam per kw.-hr. of the gas engine.

The utilization of the heat in the cooling water is not possible as directly as this. The further use of this heat means the generation of steam and this requires a considerably higher temperature than is customary in large gas engines. Semmler suggested, ten years ago, that gas-engine cylinders be cooled with water hotter than 212 deg. F., and that this water be put under pressure in order to avoid the generation of steam in the jacket. Evaporation commences only outside of the jacket, when the superheated water is conducted through a throttle valve into a steam drum. About a year ago it was decided at the Rombacher Hnetten Werke to try Semmler's cooling method on an 800-kw. tandem engine. The results in operation, which are available today, are entirely favorable. The hot jacket not only did not hurt the cylinder, but it produced softer and more quiet operation.

REFRIGERATION DEPARTMENT

Relation of Cold Storage to Plant Capacity

The above is the title of an interesting paper read by John E. Starr at the seventh annual convention of the Eastern Ice Association, held in New York City from Nov. 6 to 8, inclusive. In the introduction the author discussed the monthly load or sales, pointing out the actual or probable distribution of the load throughout the year, and showing what storage capacity would be needed with a plant output considerably lower than the maximum demand. If only the general public is to be considered, and there are no unusual demands, such as fish or car icing, the average sale of ice year in and year out, and consequently the load on the plant for a decade, may be safely based on the mean monthly temperatures given by the U. S. Weather Bureau. If in the territory south of the fortieth parallel of latitude 32 is subtracted from the mean monthly temperature of each month, the resulting twelve numbers added together and the percentage of each number taken of the whole, the results will give very closely the percentage for each month of the total sale. In territory north of the fortieth parallel 30 is subtracted arbitrarily from the mean monthly temperatures and the percentages obtained in the same way. Using this method for any plant makes it possible to determine how much storage will be needed to run the plant almost continuously and store the surplus in the colder months. Two good examples of plants having the load line of New York City were cited by the author. Based on 32 years' average of mean monthly temperature, the distribution of sales or load on a plant having a capacity of 3100 tons in its maximum month figures about as given in Table 1.

TABLE 1. DIVISION OF LOAD ON 100-TON PLANT

	Per Cent.	Tons
January	2	364
February	2	364
March	3	546
April	5	920
May	8	1,456
June	15	2,710
July	17	3,100
August	17	3,100
September	14	2,548
October	8	1,456
November	6	1,096
December	3	540
Total		18,200

The table shows that in the months of January and February only 2 per cent. of the total annual output is sold, and the months of July and August have the maximum output of 3100 tons, which is 17 per cent. of the total. Multiplying 100 by 365 and dividing the total output, 18,200 tons, by this product, gives 49.8 per cent. as the annual load factor.

If instead of putting a 100-ton machine at work on a 49.8 per cent. load factor, a 50-ton machine were used on somewhere near an 100 per cent. load factor, and the surplus stored from January to May inclusive, the results shown in Table 2 could be obtained. The table is based on a refrigerated storage house having a capacity of about 5300 tons, and on the assumption that a machine making 50 tons in July and August would make about 55 tons in the winter months.

TABLE 2. A 50-TON MACHINE AND 5300-TON STORAGE FOR AN ANNUAL OUTPUT OF 18,200 TONS

	Sales Tons	Capacity Tons	Short	Stored
January	364	1,685		1,321
February	364	1,540		1,176
March	546	1,685		1,139
April	920	1,650		730
May	1,456	1,643		187
June	2,710	1,590	1,120	
July	3,100	1,550	1,550	
August	3,100	1,550	1,550	
September	2,548	1,550	998	
October	1,456	1,550		94
November	1,096	1,550		454
December	540	1,685		1,145
	18,200	19,228	5,218	6,246

The schedule in Table 2 allows for a shutdown of 20 days in the year, and, although this is feasible with a well built plant, an extra compressor might be considered by some as wise insurance. The necessary overhauling could be done in the early part of December.

Which of the two plants will pay better depends on the following factors: The cost of ground, the cost of buildings, the cost of equipment, the shop cost of ice, and the maintenance and replacement. This omits administration and officers' salaries, and confines the comparison to the total cost of ice delivered on the platform.

As a basis of what has been done, the author took a specimen year from the books of an ice factory having the New York load line. In this place the condensing water was a mixture of well water and city water averaging about 71 deg. The storage was for about 160 tons on end, and the sale 18,020 tons per year. The cost of coal was $2.85 per ton in the bunker. The plant was equipped with a compound engine and an auxiliary distilling apparatus. Table 3 gives the cost from the books for an average year.

TABLE 3. ACTUAL COST FROM BOOKS

		Cents per Ton
Coal	$5310	29 5
All labor, including repair labor	6420	35 6
Ammonia	270	1.5
City water	720	4 0
Repairs, material, oil, etc.	484	2 7
Total shop cost	$13,204	73.3

Mr. Starr did not know what had been done about an extraordinary repair fund and replacement, taxes and insurance, but assumed the charges given in Table 4 on the buildings, which cost $18,000, and the equipment costing $69,000.

TABLE 4 ASSUMED FIXED CHARGES

Buildings, 2 per cent.	$360
Reserve for extraordinary repair, accident and unusual loss of ammonia, 5 per cent.	3,450
Replacement, 6 per cent.	4,140
Taxes and insurance, 3 per cent. on $85,000.	2,550
Assumed overhead 58 4c. per ton	$10,500
73 3c per ton	13,204
$1.317	$23,704

The plant and the ground it was built on cost the owners $95,000. For the sake of comparison with the 50-ton plant and storage, selling the same amount of ice, a platform price of $2.50 per ton was assumed. Then, as the total output was 18,020 tons, the income for the year

would be $45,050. Deducting the operating and fixed charges of $23,704 leaves a gross profit of $21,316, which is 22.5 per cent. on the investment. Out of this, officers' salaries, office force and profits must be paid.

The nearest example to the 50-ton and storage plant, of which the author had actual figures from the books, was a plate plant operated by an absorption machine with water at 60 deg. F. and having a nominal capacity of 42 tons. The plant was operated for 330 days on a load factor of 91.5 per cent., and the actual ice made per year was 14,044 tons. The shop costs are given in Table 5.

TABLE 5. SHOP COSTS OF 42-TON ABSORPTION PLANT

		Cents per Ton
Coal	$3,315	23.6
Labor	4,978	35.45
Oil and waste	305	2.10
Ammonia (extraordinary)	1,877	13.37
Repairs (extraordinary)	1,602	11.40
	$12,077	85.92

The extraordinary ammonia and repair accounts of this year are abnormal, due to worn-out coils, which caused a great loss of ammonia. The replacement of these coils made the repair account up to the limit of what this item would be. The coal account is low, as steam for driving the auxiliaries was exhausted into the generator and little live steam was used. The water was 11 deg. colder than in the case of the 100-ton machine previously cited.

If the water had been at a temperature of 71 deg., as in the case given in Table 2, the cost of coal would have been greater, so to put the data on a comparative basis the data in Table 5 were modified. The cost of coal was made 30c. per ton of ice, instead of 23.6c. The ammonia and

TABLE 6. OPERATING COSTS OF 50- TO 55-TON MACHINE OPERATED AS IN TABLE 2 AND RUNNING 345 DAYS WITH ICE STORAGE OF 5200 TONS AND ANNUAL OUTPUT OF 18,200 TONS

		Cents per Ton
Fuel	$5,460	30
Labor	6,461	35.45
Oil and waste	382	2.10
Ammonia	728	4
Repairs, ordinary	546	3
Shop cost	$13,577	74.55

repair charges were reduced to a normal figure. With these modifications the results given in Table 6 were obtained. The cost of the equipment was $40,000, cost of buildings $11,000, cost of ice house $25,000, and cost of the ground $8000, making a total of $84,000. Table 7 gives the fixed charges, which amount to $7640. Adding to this the shop cost of $13,577, and the cost of handling and refrigerating 5200 tons of storage ice at 15c. per ton, amounting to $780, gives a total for the year of $21,997. Dividing by 18,200 gives a cost per ton of approximately 1.21c. Assuming, as before, a selling price of $2.50 per ton, the net income will amount to $45,500, and deducting the gross expense of $21,997, leaves $23,503 as the gross profit, which is 28 per cent. on the investment. Out of this profit, as before, must come administration and office charges.

Summarizing on these two plants, the 100-ton machine without large storage, costing $95,000, yielded a gross annual profit of $21,346, exclusive of administration charges, or 22.5 per cent. on the investment. The 50-ton

TABLE 7. FIXED CHARGES

Buildings—$36,000, 2 per cent.	$720
Extraordinary repair on $40,000, 5 per cent.	2000
Replacement on $40,000, 6 per cent.	2400
Taxes and insurance on $84,000, 3 per cent.	2520
Total	$7640

machine and large storage yielded $23,503 on an investment of $84,000, or 28 per cent. In these two cases the argument seems to be in favor of the small plant and storage, but it would not be safe to say that this would always be the case. The figures might be greatly modified by the cost of ground, the cost of the water supply and the character of the water. The cost of the coal in the two cases cited was not over $2.85 per ton, and there was an abundance of water which did not exceed 71 deg. F. in the hottest months. Depending on the location of the plant, the price of coal might easily vary from $1.30 to $4 per ton, and the temperature of the water from 60 to 85 deg. F. If coal was $4 per ton and water at 85 deg., it would mean that the fuel in the two plants just cited would cost 51.9c. per ton instead of 30 cents.

On the other hand, in a raw-water plant with a compound condensing engine and using 4 gal. of 59-deg. water per ton, with coal costing $3.05 per ton, 1740 tons of raw-water ice had been made with 127.5 tons of coal, costing $388. For water pumping, lighting, ice handling and taking care of the refrigeration of 4000 tons of ice, the cost was $90 more, making a total power cost for all purposes of $478. This averages a little over 27c. per ton for power alone for all purposes.

In the South, with oil at 90 to 95c. per bbl., and water at 78 to 80 deg. F., it costs from 80 to 90c. for fuel per ton of ice. The ordinary repair and extraordinary repair with warm water is also greater than with cold water.

It is thus apparent that the cost of production depends a great deal on the location of the plant, the water, and the cost of coal, so that the particular type of plant to install will largely depend on local conditions.

Cost of Power for Ice Making

It is not the writer's intention to take up the cause of the Brooklyn Edison, but instead to point out to Mr. Bigelow and those who have read his communication a fallacy in his argument. He states in part: " . . . it would be just as reasonable for the trolley companies and suburban railroad companies to insist that they should charge more for transportation during the rush period than they do during the nonrush hours." In the first place, trolley and railroad companies in their passenger divisions are not selling transportation, but transportation plus service. The class of cars, stations, waiting rooms, etc., furnished to passengers, as well as the extent or efficiency of porter service, information bureaus, etc., are factors entering into service and not into transportation. Furthermore, during rush hours the rates become automatically higher than during nonrush periods, for, although 5c. will normally pay rental for a seat in an urban conveyance between 10 and 11 a.m., it does not by any means insure the passengers even having a strap to cling to between 5 and 6 p.m.; nor would it be possible for public-service commissions or courts to require that the service at the two periods be entirely similar, if a flat rate were to be maintained.

During rush hours, or peak loads, on a telephone system, wires may be incessantly "busy," and on a telegraph system messages be sent in the order of their receipt or importance. The rate may be no higher for one period than the other when duration of conversation or cost per word is considered, but the cost of service is undeniably increased.

Fortunately, central stations cannot report to a customer that the lines or stations are "busy" during rush

hours, or in any way make a difference in the quality of the service rendered, but they can, and are entitled to, charge an adequate rate for the service.

He further states: "The practice of the central station is to charge anywhere from ½c. to as high as 15c. per kw.-hr. In almost every other business, such as transportation, communication, etc., such discriminatory rates have been shown to be illegal. Probably they will be so held in connection with light and power before long in many of the states." Mr. Bigelow might have to advantage omitted the word "such," for simply because a rate varies does not necessarily mean it is discriminatory. The government postal rates are 2c. an ounce for first-class matter, and 1 oz. for 1c. for second-class matter—a difference of 8:1. If this is discrimination it affects many more than merely "50 helpless small users" and Mr. Bigelow should lend every effort toward any movement which will stamp it out or at least lessen the difference between the two rates.

CECIL W. BROWN.

New London, Conn.

Direction of Flow in Brine Cooler

Mr. Hooper in his article on the "Direction of Flow in Brine Cooler" in the Nov. 11 issue is correct in his contention that the brine and ammonia should flow in opposite directions so as to bring the warm gas and brine at one end and the cold gas and cold brine at the other. Practically all ammonia and brine double-pipe coolers are arranged on the counter-flow principle, and I believe Mr. Hooper will find that he will obtain better results if the flow of brine were reversed.

It would also be better to use one pump for one machine and the other for the other, but so connected that in case of one pump going out of service the second could be used temporarily on both machines.

W. L. DURAND.

Brooklyn, N. Y.

In the shell type of brine cooler better results are sometimes obtained by allowing the brine to flow up instead of down through the cooler as is the general custom. If the cooler is so operated that superheated vapor leaves it, it is better to bring the warm brine in at the top, but when saturated and even wet vapor leaves the cooler, better results may be obtained by bringing the warm brine in at the bottom, for the following reasons:

To obtain a flow of liquid and vapor through the cooler, a pressure difference must exist in it. The vapor outlet being at the top, the pressure there must be less than at the bottom where the liquid enters, and, consequently, the temperature of the saturated vapor at the top is less than that of the boiling liquid. At about zero gage pressure the boiling point of the liquid ammonia is raised 1 deg. F. for an increase or decrease of less than ½ lb. in the suction pressure. Furthermore, a shell-type brine cooler, properly installed and constructed, will contain a considerable quantity of liquid ammonia, when in full operation, which still further increases the pressure difference between the top and the bottom of the cooler. When they are used in connection with absorption machines, it has been found best to bring the warm brine in at the bottom, in order to obtain a more active evaporation of the slightly impure anhydrous ammonia, which necessarily results from the operation of such a system, as it is impossible to remove all the water vapor brought over from the generator.

In this case I do not believe that the results will be bettered by a change in the direction of flow of brine, for the reasons above given.

If there is trouble in boiling off the liquid in the brine coolers, it is probably due to a considerable percentage of water being contained in the liquid. The boiling point of this mixture is higher than that of the pure liquid. This difficulty can be overcome by frequently purging the brine cooler and also by so adjusting the operation of the rectifier that the temperature of the ammonia vapor entering the condenser is not more than 10 deg. above the boiling point of the liquid ammonia at the condenser pressure.

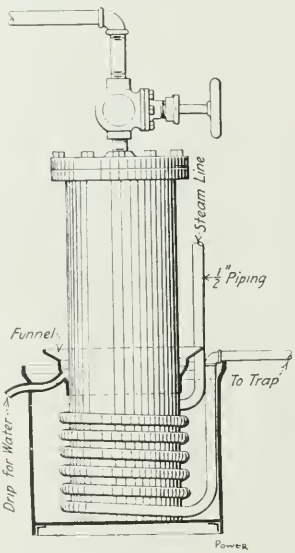
With regard to the operation of the brine coolers when operated in parallel with two brine pumps, it would be advisable to so cross-connect the pumps and coolers that either pump can be operated on either cooler, independently. It is difficult to so arrange the piping connecting the coolers and the pumps that the flow of brine is equally distributed between the two coolers, even though they may be of the same capacity and identical in construction.

FRED OPHULS.

New York City.

Preventing Corrosion of Ammonia Purifier

Our ammonia purifier only lasted four years. It was pitted so badly at the end of that time that it was not safe to use the cylinder any longer. A new one was ordered and a funnel was put around it even with the water line in the basin and a drip provided at the bottom of this funnel to drain off the moisture from the frost, etc. A ½-in. pipe was also wound around the bottom of the cylinder and the lower end run back up over the basin and connected to a trap. Then the basin was filled with oil. This arrangement has been operated for a year with no sign of deterioration. As will be apparent the coil is supplied with steam to heat the contents of the purifier and facilitate the process. Oil instead of water is used in the basin as it will not evaporate so readily.



METHOD OF DRAINING OFF MOISTURE

ALBERT WARNER.

Appleton, Wis.

EDITORIALS

Taking Pains in Designing

In no branch of engineering is accuracy of detail more important than in the design of power plants. The operating engineer knows to his sorrow that, unless complete working drawings are provided, the installation is certain either to give trouble when the construction force puts it together or to cost much more than it should.

In the extension of a plant, for example, it is hazardous to attempt to do the work without correct drawings of apparatus location, particularly where alterations in the situation of equipment enter the problem. Take the single matter of flue connections. Unless these are carefully designed, with due regard to expansion and contraction, inspection, subsequent accessibility for repairs and replacements, and, above all, to the elimination of leaks around joints and the minimizing of internal friction losses, either the cost of the completed work will be excessive or the plant efficiency will suffer. Extra plates and angles in breeching may not be expensive in themselves, but where they have to be used on account of poor fits or too little care in the making of preliminary measurements in the boiler room, they introduce eddies and back currents in the path of the gases going to the stack and cut down the draft accordingly.

It is an old definition of engineering to denote it as the art of making one dollar do the work of two, but there are still too many people of the opinion that money saved in cutting down preliminary drawings and measurements is real engineering economy. The power-plant operator well knows that much hard work with the tape and scale must be done in any job of planning to remodel an existing active installation for the production of steam or electric power. It may not be necessary to locate every pipe to the last inch, but unless the plans are prepared by somebody who knows just how much total space different sorts of piping and equipment demand, backed up by close personal investigation on the local site, the chances of misfits, exaggerated sizes in passages, cramped apparatus units, and inconvenient layouts of heavy pipe in places hard to reach are almost certain to result. In the past there has been too much reliance upon the general drawing, which covers a multitude of sins of omission, and too much reliance upon the abilities of the contractor along the lines of harmonizing equipment locations into one grand symphony of concordant operation.

Whether the plant owner realizes it or not, the task of altering a complex installation while keeping service intact is a man's job, and, to get the best results requires the united efforts of the man behind the throttle and the fellow on top of the drawing board. The concern which lets its operating staff in on the ground floor when betterments are planned and set in motion by the aid of outside advisers; which has the breadth of view to select the best ideas put forth, regardless of whether they come from the coal passer or from the head of the consulting firm; and which resists the temptation to hasten construction on the basis of insufficiently detailed drawings and specifications is the one which really conserves its resources and saves money in the long run.

Attention to Blowoff Valves

In this issue a contributor tells of how he was unable to close a blowoff valve he had opened to let water out of a priming boiler. A pocket knife, which had evidently been left in the shell, found its way to the blowoff pipe and, when the valve was opened, was carried into the valve and wedged there. As there was no blowoff cock or second valve on the line, the fire had to be drawn to prevent burning the shell after the water had drained out.

This case is only one of many similar near-accidents due to blowoff valves being held open by foreign substances, such as waste, nuts, pliers, parts of overalls, etc.

The pockets of overalls usually wear through quite quickly, owing to their being "worked at considerably above rating" as one might term it. Further, they are wide and too shallow, allowing such things as a pocket knife, small, flat monkey wrench, screwdriver, etc., which engineers usually carry, to easily fall out. With pockets filled with such things and the inevitable "bunch" of waste hanging half way out, it is not only possible but very probable that something will be "squeezed" out as the wearer wiggles himself through a manhole. If such things drop out as he enters the boiler, he will undoubtedly find them as he begins cleaning or inspecting.

Being cramped in a boiler is not conducive to comfort, especially if the dry pipe leaks, and one is always glad and anxious to get out. It is in the haste of getting out that things dropped from the pockets are likely to be left behind.

Another practice that has nothing to commend it is that of having the night watchman blow off the boilers before the engineer or fireman arrives.

The Gas-Engine Outlook

Many who listened to the discussion at the recent meeting of the Gas Power Section of the American Society of Mechanical Engineers doubtless detected beneath the apparent optimism of the remarks in general, a feeling of apprehension as to the future of the gas engine.

For many years this type of prime mover was handicapped by features of design, but these seem to have been successfully overcome. Another obstacle, with certain kinds of gas, has been the presence of tar; but with the more approved methods of cleaning and careful attention on the part of the operator this has been reduced to a minimum. The limitations now appear to be chiefly commercial and in spite of its high thermal efficiency, the gas engine has failed to meet the predictions of its most enthusiastic advocates.

In the small and medium sizes, although apparently holding its own, the gas engine is at a disadvantage com-

ared with the steam engine, where there is a demand or exhaust steam. Obviously, the solution lies in the ccessful utilization of the waste heat; that is, from the oling water and the exhaust gases, but more particular- the latter. Little has been done in this country along is line, but the problem is now actively engaging the ttention of European engineers and some progress has een reported.

For large powers, however, the steam turbine seems o be in undisputed possession of the field (exclusive of ydro-electric plants) and the gas engine, except for spe- ial service, such as in steel mills, occupies a position nalogous to the large steam engine. In other words, its mitations as to size have been reached and the present emand in central-station practice is for large units and igh speed.

The future of the internal-combustion engine for large owers apparently lies in the development of a successful as turbine. A number have been built, but as yet have ot reached the commercially successful stage. But when t is recalled that the evolution of the steam turbine oc- upied a long period of years, there is no occasion to be- ome discouraged over the progress of the gas turbine.

Mr. Pinchot's Views on the Hetch-Hetchy Grant

After ten years of controversy over the subject, the Jnited States Senate passed the Hetch-Hetchy dam-site ill on Dec. 6. The bill was passed by the House of Repre- entatives several months ago. At the time of going to ress, however, it has not yet been signed by the President. t authorizes the city of San Francisco to acquire a new nunicipal water supply by building a dam in the Yosem- te National Park, one hundred and sixty miles from he city, which will store the flood waters of the Tuolumne River. The dam will be three hundred and twenty-five eet high, and the reservoir created will be from seven to ight miles long and one to one and a half miles wide, vith a capacity of seven hundred and fifty thousand acre- eet. This reservoir is expected to furnish the city with a water supply of four hundred million gallons a day, and t is estimated that it will cost the city seventy-seven mil- ion dollars to complete the project. At a special election a few months ago the people voted for a bond issue of orty-five million dollars to begin the work.

Army engineers estimate that the city will be able to generate one hundred and fifteen thousand horsepower as a byproduct of the water-works. The bill passed by Con- gress requires the city to make provision for allowing the full natural flow of the stream to be used for irrigation, and for furnishing electric light and power at low cost to irrigationists. San Francisco is to build roads into the Hetch-Hetchy Valley, which has been almost inac- cessible, and around the lake to be created. Sale of water and electric current by the city, to other municipalities and to private users, is to be subject to regulation by the Department of the Interior, and the taxes exacted by the government will be governed by the quantity of electricity generated and the rates charged.

Although it was shown that less than three hundred people a year have visited the Hetch-Hetchy Valley, which is described as a swampy section at about three thousand feet elevation, hot and mosquito-infested, a group of nature lovers made a desperate fight against the passage of the bill, on the ground that the dam will desecrate and destroy the beauty of the valley. Thousands of dollars were spent by the nature lovers in a lobby fight against the legislation, and San Francisco people alleged that much larger sums were secretly spent in opposition to the measure by the private water and power companies which now monopolize the city's water supply, and largely monopolize the hydro-electric power on the Pacific coast.

The bill was approved by Franklin K. Lane, Secretary of the Interior; Secretary Houston, of the Department of Agriculture, and Frederick A. Newell, chief of the Reclamation Service. Gifford Pinchot, former chief forester of the United States, and the leader in the conservation movement, actively supported the passage of the measure. When interviewed by a representative of POWER, after the passage of the bill, Mr. Pinchot said:

"I regard the passage of the Hetch-Hetchy bill as a distinct victory for conservation and good government. Conservation means use of natural resources for the benefit of the greatest number; neither exploitation for the benefit of a few, nor the holding from use. San Francisco needs a better water supply and the Hetch-Hetchy is the best and by far the most economical supply available, and certainly water can be put to no higher use than for domestic purposes.

"If the natural beauty of this valley is at all injured by substituting a lake for the present swampy floor of the Hetch-Hetchy, it is, in my opinion, altogether unimportant as compared with the benefits to be derived from its use for a reservoir. If less beautiful, which I doubt, it will be far more accessible after San Francisco has built the roads required under the grant. It is not true that San Francisco has been given control of any important part of the Yosemite Park, and the grant will in no wise affect the beauties of the Yosemite Valley, which are far removed from Hetch-Hetchy."

"Much of the opposition to the Hetch-Hetchy bill, it is asserted, has had its root in the unwillingness of water power and transportation interests in and around San Francisco to see the city get possession of the large hydro-electric power it will be able to develop from the proposed dam. I believe the public welfare will be better served by use of the Hetch-Hetchy Valley—a use which will not destroy its beauty—rather than by keeping it untouched for the benefit of the very small number of comparatively well to do people to whom it has been accessible. The fight of the nature lovers has been for the esthetic enjoyment of less than 1 per cent. of the people against the daily comfort and happiness of 99 per cent. When they come to see the actual results of the grant, after the excitement of the contest is over, I am certain that they will be glad and not sorry that the bill was passed. They have made a very lively fight, and were fairly beaten, and as good citizens I feel confident they will accept their defeat without bitterness. In passing the bill, I believe Congress has acted wisely and well and in the interest of all the people."

Those desiring the index of POWER for the second half of 1913 may send in their names at any time. The index will be ready to mail as soon as possible after the appearance of the last issue of the present volume.

READERS WITH SOMETHING TO SAY

Averaging Recording-Gage Records

Referring to the article by Lloyd W. Taylor published in POWER for Nov. 11, and relating to the averaging of recording-gage records, it is unfortunate for the casual reader that the author does not more clearly draw a distinction between methods and formulas which are exact in principle and those which are only approximate and which will of necessity involve an error which may be large or small depending on circumstances.

The method proposed by Mr. Taylor is fundamentally the same method which has been proposed by various writers and under various forms and depends on exactly the same principle as indeed must all methods which attempt to derive a mean polar ordinate by the use of the ordinary area planimeter.

These methods substitute the square root of a mean square for the simple mean, an assumption which is fundamentally in error. The magnitude of the error will depend on the character of the diagram and may be important or unimportant according to circumstances. The point of chief importance, however, is that when the reader of an engineering paper is given a rule or a method for doing something he should be told plainly whether the method is correct in principle or otherwise to the end that he may know exactly the sources and character of the errors liable to be encountered.

In the case of the method proposed by Mr. Taylor the procedure is simply a program for finding the radius of the circle whose area is equal to that of the actual diagram, and then expressing the equivalent of this radius in scale divisions. The central feature of the whole program is the determination of the radius and the use of this radius as the mean for the irregular diagram. This is exactly the use of the square root of a mean square instead of the true mean.

The procedure specified seems needlessly long and complicated. For those who may desire to use the ordinary planimeter the following method will be found the exact equivalent of Mr. Taylor's, requiring the use of no special table and only three steps, as follows:

1. Find with the common planimeter the area of the diagram in any convenient units, say, square inches.

2. Find by suitable procedure the value of r. This will be the radius (in inches) of the circle of equivalent area.

3. Lay off on the chart this distance as a radius from the center, and the point thus determined will give, according to the reading on the chart, the value sought. Or, if more convenient, from the radius found in (2) subtract the radius of the zero circle and lay off the remainder along a radial line from the zero circle. The result will be the same.

The common type of planimeter is exact in theory for finding areas and the only errors involved in its use are those due to instrumental imperfection and to personal error in manipulation. When the attempt is made to use the instrument for averaging radial ordinates there is of necessity added an error of theory or of fundamental principle, and this error, however disguised, is essentially that of taking the square root of a mean square instead of a true mean. Similarly the radial averaging instrument is exact in theory for finding the mean radius of a diagram drawn in polar coördinates, and the only errors involved in its use are those due to instrumental imperfection and to personal error in manipulation. If an attempt were made to use this instrument for the determination of area, there would be added a further error of theory or of fundamental principle.

If, then, the common planimeter is to be used for averaging polar diagrams it should be with a full recognition of the source and character of the error in principle which is involved, and it should not be so employed with the idea that the resultant errors will be limited to those which characterize its use for the determination of areas.

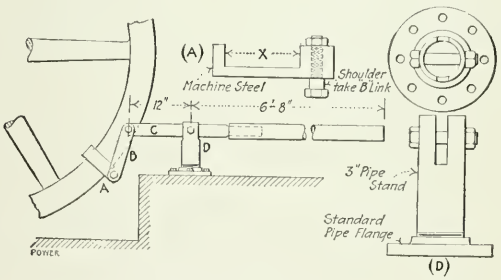
W. L. DURAND.

Brooklyn, N. Y.

A Simple Flywheel Jack

A few years ago the writer was serving as assistant engineer in a large power house and one of the daily bugbears was the turning over of a 500-hp. horizontal tandem steam engine. The difficulty was finally overcome by making the simple flywheel jack shown in the accompanying sketches.

The part A is of machine steel and should have its inner faces well cut, similar to a file so it will take a good "bite" on the flywheel rim. A few general dimensions



DETAILS OF ENGINE JACK

are suggested in the drawings, but these will vary with the size of the engine to be turned over. This flywheel was a ponderous affair, but the jack turned it over easily. The main lever may be of wood. We used a piece of 2-in. steam pipe. The jack parts A, B, C and D were made up in the machine and forge shops.

In operation the action of lifting up on the long lever automatically lets the clutch shoe A drop down for another hold on the flywheel rim. The inside span of the shoe A, as the dimension X, should be about $\frac{3}{8}$ in. more than the thickness of the rim, for a large rim. For

smaller rims, say, about 2 in. thick, the dimension X may be about $\frac{1}{4}$ in. greater than the rim depth. The standard D is made of a short length of 3-in. pipe.

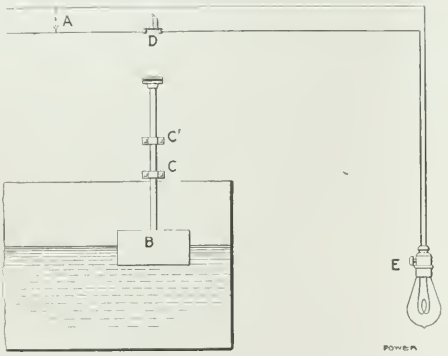
H. W. Secor.

New York City.

Another Water-Level Indicator

A simple and reliable water-level indicator is here shown. When the reserve or supply tank is located where it is not visible from the pump house, some method should be used to indicate the height of water in the tank.

The indicator herewith illustrated will show when the tank is full. Branch wires A from an ordinary lighting



Water-Level Indicator

circuit are run to the tank and continued to the pump house, or to several stations if required. A copper float B is attached to a rod, the top of which has a brass plate. The rod should be insulated from the plate and guided by clamps C and C'. When the tank fills the rod will close the lighting circuit by bridging the space at D and the lamp E will light. By attaching an arm to the float rod it can be arranged to also show when the tank is empty by taking a couple of drop wires from the line A on the lamp side and arranging a break like D near the upper strap or guide.

James E. Noble.

Toronto, Ont., Can.

Buckling of Boiler Tubes

I read with interest the discussions under this title which have appeared in Power during the last few months and have studied the subject and made observations thereon.

I believe that the upward buckling of tubes in horizontally baffled water-tube boilers is due, primarily, to the fact that nearly all the heat absorbed by the water in passing through a tube is taken from the lower half, thus keeping this part cooler and shorter than the upper half. This conclusion is supported by the following facts:

The upper part of the tube is in contact with a mixture of steam and water, which is a poor conductor of heat. The bottom of the tube is in contact with water. The efficiency of heating a liquid, as water, by convection is immensely greater than that of heating a mixture of vapor and water by conduction.

Therefore, since the lower part of the tube offers the more efficient avenue of escape for the heat, it follows that the rate of heat transfer therefrom is much greater than from the upper part and it is, consequently, at a lower temperature. Much of the heat absorbed by the top of the tube is conducted toward the bottom before it enters the water.

I measured the deformation of the tubes in three 150-hp. horizontally baffled boilers and found that in all the tubes were buckled upward, that the buckling was greatest in the lower row, that the middle tubes of each row were buckled more than the outer ones and that the tops of the bends in the lower row were about 4½ ft. from the front water leg.

That the middle tubes were the most buckled may be explained by the fact that, they being directly under the steam drum, the circulation was more direct and better than in the outer tubes and that the better the circulation the greater the rate of heat transfer from the bottom of the tube and the greater the temperature difference between the top and bottom. Also, the gases are probably hotter away from the walls of the setting.

That the lower row buckles most may be due to the radiation from the fire heating the baffle tile, which conducts the heat to the top of the tube.

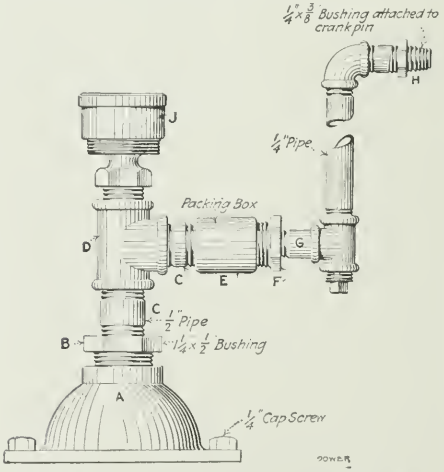
In vertically baffled boilers the heat flow from the furnace gases into the water is much more complex than in horizontally baffled boilers, therefore, its effect in deforming the tube may also be expected to be more complex.

Keller Shank.

Fort Wint, P. I.

Grease Cup for Crankpin

In our plant we have a 12x12-in. engine running 150 r.p.m. and driving a 70-kw. generator furnishing current for motors driving centrifugal pumps and for lighting. As this engine sometimes has to run 12 hr. without a stop and as we had only a common grease cup on the crank



Grease Cup for Lubricating Crankpin

which was impossible to fill when the engine was running, I made the device shown, which is simple and gives good satisfaction as the grease cup is stationary.

In the drawing, *A* is a foot flange for 1¼-in. pipe used for fastening railings to the floor. *A* ½x1¼-in. bushing *B*, ½-in. nipples *C* and *C''*, and a ½-in. tee *D* are used. The ½-in. coupling forms the stuffing-box, the end of the nipple *C''* making the bottom against which the packing rests. The bushing *F* forms the gland, which is ½x⅜ in. The ¼-in. pipe *G* slips inside the bushing and is threaded on one end only, the other end turning in the stuffing-box. All the other fittings shown are ¼ in., except the bushing *H* and the cup *J*.

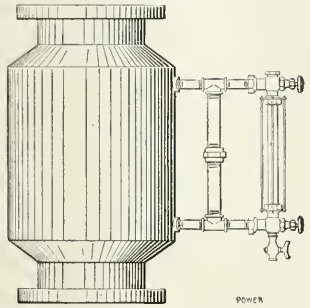
PERRY BARTRAM.

Cedar Point, Ill.

Preserving Separator Gage-Glasses

Nearly every engineer knows that it is difficult to keep the glass gages in steam separators from breaking.

Many causes for the breakage of these glasses are assigned, but my theory is that the changing velocities of the steam flowing through the separator is principally



CIRCULATING PIPE TO PREVENT BREAKING OF SEPARATOR GAGE GLASS

accountable for the breakage of the gage-glasses. These velocity changes occur so rapidly as to create a partial vacuum in the glass on account of its small area. Though it lasts only for an instant, the temperature is reduced sufficiently to produce a cracked glass. Perhaps one or a number of the changes would not break the glass, but a number of them occurring continuously, especially as often particles of water adhere to the sides of the glass, cause the glass to break.

The pipe at the side of the glass in the illustration allows for enough additional circulation to nullify the conditions referred to above, and leave the temperature of the glass somewhat constant.

W. OLIVER.

Bethlehem, Penn.

Pocket Knife in Blowoff Valve

Upon entering the boiler room I noticed an unusually high-water level in one of the boilers. As I had had trouble with the boilers priming, due to the heavy load on them, it was necessary to keep the water as low as possible, so I proceeded to open the blowoff valve, but I was unable to close it when the water fell to the proper level. The fire was pulled and the boiler cut off from the line, after which I examined the valve to learn the cause of the trouble. The valve referred to is an angle valve, and I found a pocket knife lodged between the valve and its seat.

There are two lessons to be learned from this little incident, the first is that we should be very careful to leave nothing in the boiler that can enter the blowoff pipe when washing out, second, that there should be two valves in the blowoff pipe, so if one fails the other can be put into service. This incident took place in an ice plant and I was obliged to shut down one of the ice machines while the boiler was being put back in service. A shutdown of three or four hours means much in an ice plant, especially in the busy season.

E. O. HAMILL.

Salem, Ohio.

Linseed Oil for Hot Journal

Troubled with a hot crankpin, I tried all of the customary methods with but little success. Noticing a can of boiled linseed oil on the engine-room floor, I tried some with surprising results. Since that I have found that applications of boiled linseed oil alternately with a 1 to 1 mixture of engine and cylinder oil have given the best results in cooling hot journals.

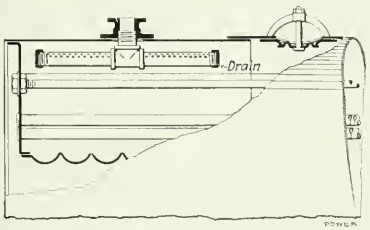
JAMES BEGGS.

Montreal, Can.

Drains for Dry Pipe

Recently I recommended a dry pipe made as illustrated to be placed inside a steam boiler to prevent priming, and suggested that a small hole be drilled on the under side of each end to prevent an accumulation of water while the boiler was standing idle. The total area of the small holes in the dry pipe should equal to double the area of the steam pipe.

The engineer in charge when the pipe was being installed advised that the drain holes be plugged. He maintained that they were an unnecessary precaution and that they affected the efficiency of the device, arguing that



SHOWING LOCATION OF DRAIN

as soon as the boiler began to steam any water in the dry pipe would absorb the latent heat in the steam and evaporate, so that before the boiler was ready to be cut in, the dry pipe would contain steam only.

Engineers seem to differ regarding this and I think it a good topic for discussion.

BURT N. EVERETT.

Jamestown, N. Y.

ENGINEERS' STUDY COURSE

Trigonometry—V

LAST LESSON'S ANSWERS

16. From equation 11 (last lesson)

$sin\ 75° = sin\ 30° \times cos\ 45° + cos\ 30° \times sin\ 45°$

Given $sin\ 30° = \frac{1}{2}$ then, by equation 1 (Lesson III) and as worked out in answer 14 (Lesson IV) $cos\ 30° = \frac{\sqrt{3}}{2}$. Also, given $sin\ 45° = \sqrt{\frac{1}{2}}$, then, as explained in answer 15, $cos\ 15° = \sqrt{\frac{1}{2}}$.

Now, substituting in the above equation

$$sin\ 75° = \tfrac{1}{2} \times \sqrt{\tfrac{1}{2}} + \frac{\sqrt{3}}{2} \times \sqrt{\tfrac{1}{2}} = \frac{1}{2\sqrt{2}} + \frac{\sqrt{3}}{2\sqrt{2}}$$

$$= \frac{1 + \sqrt{3}}{2\sqrt{2}} = 0.9659$$

Note that this agrees with the value given in the table in Lesson II.

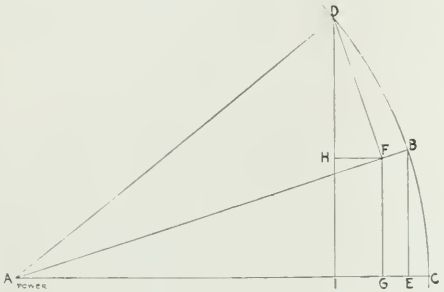


FIG. 6.

17. From equation 12,

$sin\ 15° = sin\ 45° \times cos\ 30° - cos\ 45° \times sin\ 30°$

substituting the values

$$sin\ 15° = \sqrt{\tfrac{1}{2}} \times \frac{\sqrt{3}}{2} - \sqrt{\tfrac{1}{2}} \times \tfrac{1}{2} = \frac{\sqrt{3}}{2\sqrt{2}} - \frac{1}{2\sqrt{2}}$$

$$= \frac{\sqrt{3} - 1}{2\sqrt{2}} = 0.2588$$

which also agrees with the value given in the table.

18. Required an expression for $sin\ (A + B) + sin\ (A - B)$. Substituting their values as given in equations 11 and 12

$sin\ (A + B) + sin\ (A - B) = (sin\ A\ cos\ B + cos\ A\ sin\ B) + (sin\ A\ cos\ B - cos\ A\ sin\ B)$

Simplifying

$sin\ (A + B) + sin\ (A - B) = 2\ sin\ A\ cos\ B$

19. Referring to Fig. 6, let angles CAB and BAD represent any two angles A and B, as in the derivation of equation 11. It is required to find an expression for $cos\ (A + B)$, which is AI in Fig. 6.

Evidently

$$AI = AG - IG$$

or, since

$$IG = HF$$

$$AI = AG - HF$$

By similar triangles

$$\frac{AG}{AE} = \frac{AF}{AB}$$

$$AG = \frac{AE \times AF}{AB} = \frac{cos\ A\ cos\ B}{1}$$

Also, by similar triangles

$$\frac{HF}{BE} = \frac{DF}{AB}$$

$$HF = \frac{BE \times DF}{AB} = \frac{sin\ A\ sin\ B}{1}$$

Substituting in the equation for AI

$$cos\ (A + B) = cos\ A\ cos\ B - sin\ A\ sin\ B \qquad (13)$$

Another demonstration may be made directly from equation 12. Since A is any angle, the complement of any angle may be substituted, as $90° - A$. Putting this in equation 12 gives

$$sin\ (90° - A - B) = sin\ (90° - A)\ cos\ B - cos\ (90° - A)\ sin\ B$$

But $90° - A - B = 90° - (A + B)$ and $sin\ [90° - (A + B)]$ = the sine of the complement of $(A + B)$ or $cos\ (A + B)$. Also $sin\ (90° - A) = cos\ A$ and $cos\ (90° - A) = sin\ A$. Substituting then in the above equation it reduces to the form of equation 13.

20. As in the derivation of equation 12, now let angle A be represented by angle CAD, Fig. 6, and angle B by angle CAB. Again,

$$AG - IG = AI$$

or, since $IG = HF$

$$AG - HF = AI = cos\ A$$

By similar triangles, as before,

$$AG = \frac{AE \times AF}{AB}$$

which, with the present angles, means

$$AG = cos\ B\ cos\ (A - B)$$

Also by similar triangles

$$\frac{HF}{BE} = \frac{DH}{AE}$$

$$HF = \frac{BE \times DH}{AE} = \frac{sin\ B \times DH}{cos\ B}$$

but

$$DH = DI - HI = DI - FG = sin\ A - FG$$

and by similar triangles again

$$\frac{FG}{BE} = \frac{AF}{AB}$$

$$FG = \frac{BE \times AF}{AB} = sin\ B\ cos\ (A - B)$$

then

$$DH = sin\ A - sin\ B\ cos\ (A - B)$$

and

$$HF = \frac{\sin B\,[\sin A - \sin B \cos (A - B)]}{\cos B}$$

Now substituting the values of AG and HF in the equation that equals $\cos A$

$$\cos B \cos (A - B) - \frac{\sin B\,[\sin A - \sin B \cos (A - B)]}{\cos B} = \cos A$$

Multiplying through by $\cos B$ to eliminate the fraction

$$\cos^2 B \cos (A - B) - \sin A \sin B + \sin^2 B \cos (A - B) = \cos A \cos B$$

or

$$(\cos^2 B + \sin^2 B) \cos (A - B) = \sin A \sin B + \cos A \cos B$$

or, since $\cos^2 B + \sin^2 B = 1$

$$\cos (A - B) = \sin A \sin B + \cos A \cos A \qquad (14)$$

Functions of the Sum and Difference of Angles Continued

Having now studied the sines and cosines of the sums and differences of two angles it will be sufficient to further consider only the tangents and cotangents. It is to be proved that *the tangent of the sum of two angles is equal to the sum of their tangents, divided by 1 minus the product of their tangents.*

As the tangent of any angle is equal to its sine divided by its cosine,

$$\tan (A + B) = \frac{\sin (A + B)}{\cos (A + B)}$$

Therefore, from equations 11 and 13

$$\tan (A + B) = \frac{\sin A \cos B + \cos A \sin B}{\cos A \cos B - \sin A \sin B}$$

Dividing the numerator and denominator of the second term by $\cos A \cos B$

$$\tan (A + B) = \frac{\dfrac{\sin A \cos B}{\cos A \cos B} + \dfrac{\cos A \sin B}{\cos A \cos B}}{\dfrac{\cos A \cos B}{\cos A \cos B} - \dfrac{\sin A \sin B}{\cos A \cos B}}$$

Canceling

$$\tan (A + B) = \frac{\dfrac{\sin A}{\cos A} + \dfrac{\sin B}{\cos B}}{1 - \dfrac{\sin A}{\cos A} \times \dfrac{\sin B}{\cos B}}$$

and, again, the sine divided by the cosine of an angle being equal to its tangent,

$$\tan (A + B) = \frac{\tan A + \tan B}{1 - \tan A \tan B} \qquad (15)$$

Next to prove that *the tangent of the difference of two angles is equal to the difference of their tangents, divided by 1 plus the product of their tangents.*

The demonstration is precisely similar to the last except that equations 12 and 14 are used, showing that

$$\tan (A - B) = \frac{\sin (A - B)}{\cos (A - B)}$$

$$= \frac{\sin A \cos B - \cos A \sin B}{\sin A \sin B + \cos A \cos B}$$

Again, dividing the numerator and the denominator of the last term by $\cos A \cos B$

$$\tan (A - B) = \frac{\dfrac{\sin A \cos B}{\cos A \cos B} - \dfrac{\cos A \sin B}{\cos A \cos B}}{\dfrac{\sin A \sin B}{\cos A \cos B} + \dfrac{\cos A \cos B}{\cos A \cos B}}$$

which, by cancellation and the substitution of the tangent for the sine divided by the cosine, reduces to

$$\tan (A - B) = \frac{\tan A - \tan B}{1 + \tan A \tan B} \qquad (16)$$

Study Questions

21. Show that *the cotangent of the sum of two angles is equal to the product of their cotangents minus 1, divided by the sum of their cotangents.*

22. Show that *the cotangent of the difference of two angles is equal to the product of their cotangents plus 1, divided by the difference of their cotangents.*

23. Given $\tan 30° = \frac{1}{\sqrt{3}}$ and $\cot 45° = 1$, find $\tan 75°$.

24. Given the same, find $\cot 15°$.

25. Deduce an expression for the tangent of the sum of two angles minus the tangent of their difference.

Johns Hopkins to Teach Engineering

The Johns Hopkins University has established a department of engineering made possible by a large appropriation from the state of Maryland. The state, however, exercises no control over the institution.

The new buildings now under construction are designed to offer complete facilities for graduate work in engineering, and the department aims to carry on research work in various branches of engineering. Undergraduate courses preparing students have been planned to afford opportunity for unusually thorough training. Courses have been established in civil, electrical and mechanical engineering under the direction of Prof. C. J. Tilden, formerly head of the department of engineering mechanics, University of Michigan; Dr. John B. Whitehead, formerly professor of applied electricity, Johns Hopkins University, and Prof. Carl C. Thomas, formerly head of the department of mechanical engineering, University of Wisconsin.

The engineering students will not begin to specialize until the beginning of the fourth year's work, though there will be minor exceptions to this rule. In the third year three parallel courses will be taken by all engineering graduates dealing with the broad outlines of civil, mechanical and electrical engineering. Drawing and engineering design are continued through the entire undergraduate period and laboratory and surveying courses form part of the first three years' work. In the fourth year specialization begins, but the course has been planned to avoid early specialization and of affording the student thorough fundamental preparatory training.

Those entering the undergraduate courses must have a satisfactory knowledge of mathematics, English, history, French or German, Latin (or physics and manual training); a science, such as botany, chemistry or biology; mechanical drawing. Before being admitted to the examinations, the applicant must show that he has completed courses equivalent to a four-year high-school course in these subjects.

A bachelor's degree will be given upon the completion of four years of undergraduate work. The departments of engineering will not include machine shop, foundry, etc., although some equipment will be used for illustrating manufacturing processes as part of the laboratory work. Each undergraduate student must spend at least four months in a shop or drawing office during his course, and will be advised to spend a year, if possible, in addition to attending surveying classes in the field for about five weeks during one of the summer vacations. It is expected that the undergraduate courses thus given will lead to the use of the exceptional facilities which have been provided for graduate work.

This fall 75 undergraduates and 15 graduate students have entered the engineering department. The new building will be ready for occupancy at the beginning of the college year 1914-15.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

MERRY CHRISTMAS—EVERYBODY!

A Merry Christmas to you, and yours! The merry day is here once more, son. We know it; oh! we know it, just as the first glimmer of daylight peeps from behind our bedroom curtains and we hear the soft patter of tiny feet in the hallway. Then the door bursts open and in comes our white-robed brood of little tots. They climb up on the bed and bang our bald head with a woolly lamb or a whole train of tin cars and cry: "Merry Christmas, daddy and mama; see what Santy give us!" Christmas? You bet!

Or perhaps it's our son's or daughter's kiddies who greet us on this happy morning, and we begin to wonder in sleepy fashion if the years have flown thus quickly. And we say so to the missis, while the chatter and the prattle of the little kiddies goes on— It just makes us think, doesn't it?

Of course, there are young chaps we know who are single, and know not the joys and thrills of happy fatherhood; whose lives lack the sunshine and the companionship of the real home. And they won't know, either, until they have sought out that one Her who is waiting for that Him to make the next Christmas a real one for them both.

Christmas means a lot to you and to me, and we are hoping the whole world has a share in our happiness—at the least, we are trying to feel that way, aren't we, son?

So, with Dickens' Tiny Tim we say: "God bless us, every one!" and a merry and joyous Christmas to everybody!

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One of the two Latin quotations we know is "Caveat emptor."—Let the buyer beware. It is again called to mind by its use in an electrical central-station monthly. It's a corking good suggestion to all parties concerned, even from the consumer's point of view.

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We wonder if it is one on the efficiency engineers, when a concern in New York "goes broke" trying to cut expense for others? This happened a short time ago to a concern that ended up with liabilities of $75,000 and assets of $30,000.—"Graphite."

This column is regularly dixoned with a "No. 1-151," brother, which refuses to turn against its maker, but— Is the above a slam or just airy persiflage?

⁂

There were and are quite a few prominent "noncollege" men when you come to dig them up—figuratively speaking. Herb Spencer at 26 was a locomotive engineer; how Charley Darwin got his, we know not, but he was a "non"; the first time Vambrey went to college he went to teach, and he spoke and wrote 12 Asiatic and nine European languages; Lowell told Howells he could be glad he was a "non"—might have lost his originality and become imitative; Jack London could have, but he thought a college training was narrow; good old Elihu Burritt, at 30, had mastered 50 languages, and "his student's lamp was a forge and his desk an anvil."

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"The engineer was taking his train to New York when the locomotive steam-chest exploded, drenching him with steam and boiling water. He stuck to his post and applied the brakes. When found he was unconscious, with his hand on the throttle."—Daily Paper.

Would ask how this paper thinks the engineer reached that steam chest from the cab. Perhaps the cylinder valve on the mud drum of the cowcatcher corroded and let the vacuum leak over onto the bell rope. Mebbe, while standing on a siding the locomotive chest was bitten through by a man-eating goldfish! Who knows?

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Friend Horton, of Chattanooga, is hereby thanked for the dope on this rural happening in Tennessee: Business of alarmed villagers; locomotive whistle blowing to beat the band; more business of alarmed yokels; whistle still blasting; fire, flood and pestilence predicted; engine, closely accompanied by whistle, winds its tortuous way down the dew-kissed valley to village; whistle still most continuous; engine disappears kerflop! and all is silence. Business of local paper trying to explain: "Whistle valve was caught open with engineer powerless. As the huge machine passes, two men are observed firing, which indicates that the whistle is exhausting the steam needed to propel the engine." Some whistle!

NEW PUBLICATIONS

HANDBOOK FOR MACHINE DESIGNERS AND DRAFTSMEN—By E. A. Halsey. 494 8½x11-in. pages; 120 charts and diagrams and over 400 other illustrations; 400 tables; semiflexible cloth binding. Price, $5, net. McGraw-Hill Book Co., New York, N. Y.

In his able review of Mr. Halsey's book, which we give in abstract, Prof. Dexter S. Kimball, of Sibley College says:: Every man who has had experience in designing machinery has felt the daily need of a comprehensive reference book to which he could turn either to refresh his memory on basic principles or to find help and guidance from the experience of others. The ordinary text pocket-books satisfy this need only imperfectly, but it has been answered fully in Mr. Halsey's "Handbook for Machine Designers and Draftsmen." No man, in America at least, has had such an opportunity as Mr. Halsey has had for the last 30 years, to come in close touch with the best current literature of this subject, and few possess his experience and the discriminating judgment so necessary to select from this vast collection that which will be most reliable and helpful to the designer. To this carefully selected data Mr. Halsey has added the results of his own unequaled experience and he has supplemented the whole structure with valuable aid from experts in the several branches. Naturally he has drawn upon the files of the "American Machinist" for the greater part of the collected data which he presents, partly because of his long connection with that magazine, but chiefly because it contains the best in current literature on this subject for the last 25 years. The book is, therefore very complete and eminently useful.

It is difficult to make comparisons between this book and others since it is quite different in its makeup from most books on design, but the following list of the divisions of the work will give some idea of the scope of the treatise.

MECHANICAL PRINCIPLES OF DESIGN—This chapter presents some of the more general features of correct construction for which such masters as Prof. Sweet and John Richards have so long contended.

PLANE AND SLIDING BEARINGS—The tables of allowable bearing pressures given are probably the most complete ever presented. The discussion of the relation between pressure, speed and temperature is clear and concludes with valuable diagrams for the design of bearings for perfect film lubrication. The question of proper bearing materials is fully discussed and the chapter is concluded with valuable data on bearing design from the practice of such concerns as the General Electric and the Westinghouse Electric companies, as well as data on thrust bearings.

SHAFTS AND KEYS—In addition to the usual formulas for the strength and stiffness of shafting the chapter contains a number of useful charts for applying these formulas, not only to solid shafting, but to the hollow forms also. The critical speed of shafting is fully discussed. New data on the friction of shafting are given and a subsection on keys and keyways.

BELTS AND PULLEYS—This chapter contains not only the latest theory and practice on belt driving with practical data bearing thereon, but contains much useful information on laying out belt drives, data on cast-iron pulleys and deductions for the strength of cast-iron pulleys from Prof. Benjamin's experiments.

FLYWHEELS—The most uptodate treatment of the strength of flywheels and typical designs suitable for various kinds of service.

CONE PULLEYS AND BACK GEARS—This chapter includes graphical methods as well as the usual algebraic formulas for belt lengths and also discussess the methods for obtaining geometric progression of speeds.

GEARING—Voluminous tables of tooth parts and odontographic methods are given. Full discussion of the strength of gear teeth and an excellent chart based on Lewis' work are also included; two most interesting and useful charts for reducing bevel gears to equivalent spur gears are to be specially noted. The author has also given his own well known contributions to the theory and practice of worm gearing. The treatment of spiral gearing is particularly good, and there is also a clear exposition of epicycle, or planetary gears as these are usually called.

ROPES—A complete exposition of rope and rope driving.

CHAINS—Valuable material on the new types of chains for power transmission much of which has been prepared specially by the Morse Chain Co. and the Link-Belt Co.

BRAKES AND FRICTION CLUTCHES—There is very little reliable information on this class of machinery to be had in

collected form and these sections are a valuable addition to the literature of the subject.

PIPES AND PIPE JOINTS—Complete tables of all kinds of standard pipes and pipe fittings, the usual formulas for design, and in addition the work of Professors Stewart and Carman, which is the latest information on pipes under external pressure, and which has not as yet found its way into all the literature of this subject.

HEAT—This section contains complete conversion tables between Fahrenheit and Centigrade scales, data on heat transference, etc.

STEAM BOILERS, THE STEAM ENGINE, THE GAS ENGINE—These three chapters treat these subjects not from the thermo-dynamic standpoint, but as structures or machines from the view of the designer. The data from current practice are especially comprehensive and valuable.

COMPRESSED AIR—A very complete exposition of the theory and practice of air compression with valuable diagrams and practical constructions. A noticeable feature is the clear discussion of the air-lift pump, data on which are rare.

Other chapters are devoted to ball and roller bearings, cams, springs, bolts, nuts and screws, wire and sheet-metal gages, hydraulic machinery, minor machine parts, pieces and running fits, balancing machine parts, miscellaneous mechanism, power requirements of tools, cast iron, steel, alloys, weights and materials, mechanics, strength of machine parts, weights and measures, and mathematical tables.

The book is printed on a large-sized page, the size of the type page being 7x9½ in. This is advantageous in that the book will lie open readily upon the desk and it allows ample space for large-sized charts. These charts and diagrams form one of the important features of the book. Many of the illustrations and tables are not to be found elsewhere. The presswork is most excellent, the work on the charts and diagrams being particularly good.

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National Gas Engine Association Convention

The annual convention of the National Gas Engine Association was held December 4, 5 and 6, at the Boody Hotel, Toledo, Ohio. After an address of welcome by Mayor Brand Whitlock and response by Mr. Otto M. Knoblock on behalf of the association, the first day was devoted to hearing reports of the officers and various standing committees. These showed that the association had enjoyed a substantial growth during the year, that the financial condition was unusually satisfactory and that the activities and influence of the association had been much increased during the year by the employment of a paid secretary who devotes all his time to the association business.

PROFESSIONAL PAPERS

The first formal paper was presented Friday morning by L. M. Ellis, of Ann Arbor, Mich., who presented "The Elements of a Successful Cost Accounting System." Mr. Ellis treated the matter from a very practical standpoint and especially urged that costs of production be entirely separated from selling costs so that a good factory organization might not be unjustly blamed for losses caused entirely without the production department, as for instance a disastrous advertising policy. He stated that ninety per cent. of all business enterprises fail in less than fifteen years; lack of capital, primitive management, unfair competition and old age being the usual causes of failure. His classification of the basic talents of men as leadership, making, teaching, trading and organizing was unique and led to the conclusion that as all these talents are seldom possessed by one man and are all necessary in a modern business, a one-man business is likely to be a failure.

In discussing different systems he stated that over half of the cost systems installed failed and were discarded within a year and emphasized the fact that a lot of printed blanks, however cleverly gotten up, did not constitute a cost accounting system, but that any system was bound to fail which is not a simple, commonsense, workable plan which can be put through without change of personnel.

Two hours of spirited discussion followed Mr. Ellis' paper during which it was pointed out that frequently such cost items as depreciation of plant, interest on investment, development costs and improvement of output were frequently overlooked by manufacturers in figuring production expenses, with the result that the market is demoralized by engines sold below actual cost.

In a paper, "Springs as Related to the Gas Engine," F. E. Whittlesey called attention to the necessity of properly providing for the necessary springs in gas engine design so that they may be of ample size and cool at all times. He also cited tests to show that vanadium steel springs gave fully twice the service of carbon steel springs of the same design.

"Standardization," by Joseph A. Anglada was presented by A. E. Potter in the absence of Mr. Anglada. The paper gave some of the results accomplished in the standardization of parts by other societies, outlined the necessary steps for the Gas Engine Association to take to begin the work and suggested some of the points where the work along this line might well start.

The principal entertainment features of the convention were a smoker tendered by the Maumee River Yacht Club on Thursday evening, luncheon with the Toledo Chamber of Commerce Friday noon and the annual banquet Friday evening at which short talks were given by Paul Regan, of Toledo, H. W. Jones, Chicago, Prof. W. T. Magruder, Ohio State University, Prof. G. W. Munro, Purdue University and others, H. W. Bowlens, Port Washington, Wis., acting as toastmaster.

Three members of the executive committee were elected, E. J. Perkins, St. Joseph, Mich., H. D. Lauson, New Holstein, Wis., and H. G. Diefendorf, Detroit, Mich., being chosen. The officers for the ensuing year are: R. A. Oglesby, South Bend, Ind., president, H. D. Lauson, New Holstein, Wis., vice-president; O. M. Knoblock, South Bend, Ind., treasurer and H. M. Brate, Lakemont, N. Y., secretary.

A paper on "The Basic Principles of Two-Stroke-Cycle Design," by E. W. Roberts, Sandusky, Ohio, completed the program for the day. He brought out clearly the facts that to equal the four-stroke-cycle engine the ports must be ample, the base compression fairly high and the area through the carbureter at least twice as great as with a four-stroke-cycle engine of the same capacity.

On Saturday morning the matter of standardization was continued by Wm. H. Spire whose paper "Some Advantages of Standardization" showed the advantage and economy of buying standard parts over making special parts for the same purpose.

In "Pulley Specifications," S. M. Walker, of Chicago showed the absurdities of the present system of furnishing pulleys on engines and driven machinery both at the whim of the manufacturer. He proposed a standard belt speed be adopted to which all conform, in which the same farm engine might be used with a number of machines without the necessity of continually changing pulleys.

"What the Customer Wants in Lubrication," was cleverly presented by G. K. MacEdward, of Detroit, by excerpts from letters received from owners of engines made by members of the Association. The engine user desires protection from his own carelessness, the hired man's ignorance and the inherent defects of the usual oiling devices furnished with gas engines.

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Oregon 45,000-Hp. Development

The completion of preliminary surveys for the development of 45,000 hp. within the next five years at Clear Lake, in the Cascade Mountains, 75 miles from Eugene, Ore., is announced by George S. Edmonton, hydraulic engineer of the Oregon Electric R.R., a Hill line. The construction of the first unit, of about 20,000 hp., is to begin in June, 1914, and plans contemplate getting the work far enough along to be able to work throughout the year. The first unit is expected to be in operation in two years.

Power from this point will be available over a radius of 100 miles, which means the territory from Portland almost to the California state line and well into Eastern Oregon.

The power site is midway between the Oregon Trunk line, the Hill railroad and the Deschutes River in the Willamette Valley. The site was formerly held by the Southern Pacific Ry. Co., which lost title by failure to develop within the time prescribed by the state. The Oregon Electric R.R. has already surveyed a transmission line down the Santiam Valley to Albany and is now running a survey down the McKenzie Valley.

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The annual inspection trip of the department of electrical engineering, University of Illinois, was made Nov. 23-26, under the charge of Profs. E. B. Paine, Morgan Brooks, E. H. Waldo and J. M. Bryant. The party was divided into two sections, one visiting the Keokuk water-power plant, the other, the industries around Joliet, Ill. The sections met in Chicago, where the trip was concluded after trips to parts of the Commonwealth Edison system, the Hawthorne works of the Western Electric Co., and the Illinois Steel Works.

Smoke-Prevention Campaign

The Committee on Smoke Prevention of the American Railway Master Mechanics' Association has sent out the following notice to members:

On account of the increasing importance of this matter, your committee respectfully requests that each road assign to its best authority on the subject the duty of fully answering this circular.

1. Please give full progress report covering the application and the efficiency of the smoke-preventing air jets, blower, quick-opening blower valve and arch recommended in your committee's report to the convention of June, 1913. Blueprints desired with description; also gives costs.

(In this connection your committee urges your attention to and careful consideration of the report above referred to, particularly paragraphs 108 to 119, Recommendations.)

2. Have you installed on locomotives any special devices other than those recommended by your committee? If so, please send drawings, stating results obtained and costs.

3. Have you installed any special device for handling the smoke from roundhouses? If so, please send drawings, give results obtained, cost of plant and of its operation.

4. What influence on smoke prevention has the superheater on passenger, freight and switching locomotives? State type of superheater and give coal and smoke efficiencies as compared with saturated engines, as nearly as possible.

Pension Fund for Employees

The Westinghouse Airbrake Co., Pittsburgh, Penn., has announced that, beginning Jan. 1 it would maintain a pension fund for employees and a relief system for their dependents. These benefactions are to be independent of the pension and relief to which they both contribute jointly.

The extension of the pension provisions is in the pensions to be granted widows, orphan children and other dependents of pensioners or other employees. These pensions are to the widow of a pensioner, during her widowhood, 80 per cent. of her decreased husband's pension, with 10 per cent. additional for each child under 16 years of age; the total not exceeding 100 per cent. of his pension. To the widow of an employee dying as a result of any accident arising out of or in the course of employment by the company, or of an employee dying while totally disabled as a result of such accident, a pension equal to 30 per cent. of her husband's wages, during her widowhood, with 10 per cent. additional for each child under the age of 16 years; the total not to exceed 60 per cent. of his wages. To the widow of an employee who is a member of the relief department of at least two years' standing at the time of his death, who shall die from causes other than occupation accident, a pension at the same rate. In addition, all employees of the relief department, in receipt of total disability pensions at the time of reaching the retirement age, go upon the pension roll for the same amount as if they were still in the company's service.

SOCIETY NOTES

The New England Association of Commercial Engineers held its noonday luncheon and meeting on Saturday, Dec. 13, at the Revere House, Boston, Mass., and it was well attended. An address was delivered by Frank Fessenden Crane, vice-president of the Atlantic Deeper Waterways Association.

At the Dec. 8 meeting of the Louisiana Engineering Society at Stanley Thomas Hall, Tulane University, Prof. R. S. Cocks, professor of botany, lectured upon "Southern Pines." The lecture was illustrated with lantern slides and microscopes, showing the structural differences in the varying grades of pine.

On Dec. 9, the annual oyster roast was held at Eagle Hall, Washington, D. C., by Columbia Council No. 22, Universal Craftsmen Council of Engineers. A large delegation attended from Baltimore. H. T. Morningstar, electrical engineer of the Washington Navy Yard, was chairman of the entertainment committee and toastmaster and Past National President Jones welcomed the guests and members. The enjoyable entertainment was furnished by both local and other talent.

PERSONALS

Joseph W. Peters has been appointed secretary of the board of managers of the Association of Engineering Societies with an office at 3817 Olive St., St. Louis, Mo. The "Journal" of the organization will be published from that office.

J. G. White returned Dec. 10 on the "Olympic" after six months absence in England and the Continent. Much of his time was spent in London at the home office of J. G. White & Co., Ltd. One of the important recent financial undertakings of that company is the formation of the International Light & Power Co. Ltd., a holding company owning securities in several electric light and tramway properties throughout South America.

OBITUARY

ROBERT E. BINNING

On Dec. 6, Robert E. Binning, a well known electrical engineer, died at his home in Plainfield, N. J., following an illness which began 10 months ago in Lima, Peru, where he was engaged in constructing a light and power plant. Mr. Binning is survived by his wife.

DAVID E. HAIRE

David E. Haire, a consulting refrigerating engineer, died at his home in Philadelphia, Penn., Dec. 4. For a number of years he was chief engineer of the American Ice Co. His early experience in engineering was gained in the steel mills of Ohio, Pennsylvania and West Virginia. He was a member of the Society of Refrigerating Engineers and of the Manufacturers Club of Philadelphia. Mr. Haire was 51 years old and leaves a widow, two daughters and two sons.

DANIEL M. BARTON

Daniel M. Barton, general purchasing agent of the General Electric Co., died at his home in Schenectady, Dec. 8, after a brief illness. Mr. Barton was one of the oldest employees of the company. He was born in Moriah, N. Y., in 1843, and moved with his parents to Ware, Mass. At 19 he enlisted with his brothers in the Tenth Massachusetts Regiment and fought at Fredericksburg and Gettysburg. In 1883 the Thomson-Houston Electric Co. was formed at Lynn, Mass. A brother, Silas A. Barton, was its active organizer, and three years later Daniel M. Barton became its production manager.

In 1893 Mr. Barton became assistant purchasing agent of the newly organized General Electric Co. A few years after the main office was established at Schenectady Mr. Barton was made general purchasing agent, which position he ably filled to the time of his death. He was well and favorably known in the business world, and his many friends and business associates will regret his death.

Mr. Barton leaves a widow, a daughter, Mrs. Robert E. Nivison, and three grandchildren, a brother, Silas A. Barton, of Waltham, Mass., and a sister, Vila Barton, of Northampton, Mass.

Situation for License Inspector—The Civil Service Commission of Chicago, Ill., will hold an examination, Dec. 30, for a license inspector, class H, grade II, salary $1080 to $1440. Subjects of Examination: Special subject, penmanship, arithmetic, experience, report. Duties: To inspect steam plants to see that licensed engineers and water tenders are in charge; to report the conditions found to the department daily; to notify the department regarding engineers or water tenders who have not had their licenses properly transferred, or whose licenses are not uptodate; to act as witness in court against violators reported by him; to assist in office work when required.

Waterproofing Leather—The following recipe for waterproofing leather is suggested by the "Mechanical World." Apply a mixture of four parts castor oil and one part raw india rubber, by weight. Heat the oil to 250 deg. F., then add the rubber, cut into small pieces. Gradually stir until the rubber is completely dissolved, and then pour into a vessel to cool. This waterproofing treatment leaves the leather soft and pliable.

Pc 7

POWER

Vol. 38 NEW YORK, DECEMBER 30, 1913 No. 27

The Engineer's Creed

I **Believe** in my job.

I **Believe** in my plant and the firm I am working for.

I **Believe** in myself and my ability to get results.

I **Believe** in serving my firm honestly and to the best, and respect the confidence and trust placed in me.

I **Believe** in working, not waiting, in boosting, not knocking, and in the pleasure of performing my daily duties.

I **Believe** in the purchase of honest materials and equipment, produced upon the standards of honest workmanship, at an honest price, for installation at my plant, whether it be a single valve or a compound generating unit.

I **Believe** in man and plant efficiency, in the generation of greatest power at lowest cost.

I **Believe** in keeping accurate records of the daily performances at my plant to serve the best interests of my firm and to further prove my capability as an engineer.

I **Believe** in adding daily to my store of power-plant knowledge, in keeping fully abreast of the times through the careful reading of current engineering literature, and in thus learning of new ideas, new kinks, new equipment and better methods for the benefit of myself and my firm.

I **Believe** in safety first, and in such personal care and precaution and the installation of such equipment and devices as make it possible.

I **Believe** in my fellow men, in giving each man a worthy chance, and in assisting those who are honestly ambitious and seek my aid.

I **Believe** in progress, in fairness, in courtesy, in kindness, in generosity, in good cheer and good fellowship.

I **Believe** in my home and that there is no other spot in the world which can fill its place.

I **Believe** in to-day and am proud of the work I am doing; in to-morrow and the work I hope to do; and in the future and the reward it holds for me. And believe that no man is down and out until he has lost all faith in himself.

Ferranti and His Turbine

By F. R. Low

SYNOPSIS—An interview with the man who suggested and designed the first station with large direct-connected units, with a description of his new turbine which runs on 9.4 lb. of steam per kilowatt-hour.

In most lines of thought and endeavor there are daring, imaginative pioneers, who foresee the possibilities and blaze a line across the field of coming developments in advance of the traveled road. It is not always they who reap the benefit. Their projects are often so far-sighted and their trail leads so far into the untried, that it is only after years of plodding progress has developed the trail into a commercial highway that the soundness of their judgment and the value of their leadership are assured.

The first time that I ever heard of Sebastian Z. de Ferranti was in connection with the Deptford station, near London. We were still building large electric stations with small units, run from belted countershafts, and thought we had to locate them in the center of distribution to save copper and line losses. Ferranti proposed to meet the London situation with a station situated at Deptford, seven miles from the center of the field of use of the current, and to equip it with units of 5000 kw. capacity, with the engines coupled directly to the generators. His engines were vertical compounds with cylinders 44 and 88 in. in diameter, and the armature of the generator 40 ft. over all. Current was to be generated at 10,000 volts. The units were actually built. I remember the criticism and condemnation which they evoked from conservative electricians and engineers. That they were not installed as intended was due to no fault of the engines or of the general plan, which was carried out upon a smaller scale, but to the fact that the company got only a portion of the concession which it was after, and hence had no need for such large units; but when ten years later the Seventy-sixth Street station was put down in New York, the engines chosen had precisely the same cylinder diameters, and the station carried the same high pressure, 200 lb., that Ferranti had adopted so far ahead of general usage. Quite a number of his engines were built and did good service, but he did not foresee the turbine, which has so much the advantage of them in their particular field, that their manufacture was eventually discontinued.

In January of this year, Ferranti accepted an invitation to deliver the Watt Anniversary Lecture before the Greenock Philosophical Society, in the course of which he announced that he was at work upon a turbine which had already produced remarkable results. Confident that any turbine which Ferranti produced would be full of interest, and anxious to meet a man who had thought so far ahead in the field which POWER seeks to serve, I solicited an interview and received an invitation to visit him at his home in Baslow.

When I alighted from the train at Sheffield, I was prepared to meet a man somewhat along in years, for the Deptford job was done a quarter of a century ago. But the tall, straight, hearty man who came forward with his son to meet me was still on the sunny side of 50, for he was but 24 when he did that audacious job which made his reputation international.

A motor ride of something over a half hour among the Derbyshire hills led us to the Hall, at Baslow, where about a sparkling fire, grateful, although it was in August, the family of my host awaited us.

After dinner we sat about that fire and I asked about the turbine. I wish I could reproduce here the photographs and drawings which the inventor and his two grown-up sons brought out and explained to me. That, I am promised, shall come later, when patents and commercial interests will not be jeopardized. But I am permitted to describe it as well as I can from my notes and memory.

Ferranti's turbine is a superheated steam turbine; so are most turbines, but not so much so as Ferranti's. Superheat is his motive, his theme, his essential feature. His turbine differs from the Parsons mainly in the respect that it is designed and constructed to handle superheat—a higher degree than anybody else uses initially, and then some more, before the steam becomes saturated by expansion, superheat even in the steam as it goes to the condenser.

"Of the heat required to make a pound of steam," says Ferranti, "upward of a thousand units is latent, and most of it will go as latent heat of the exhaust to the condenser. So long as you are going to make this expenditure you may as well make it carry all the useful heat with it that you can. In other words, give it all the superheat that it will carry to start with and reheat it as often and as much as you can. If you could keep this superheat pouring into it so long that the final expansion

would not cool it quite to the point of saturation, so much the better. In practice we cannot do this; we must reheat intermittently, and in the present turbine I have reheated but once."

Let us make this clearer by an example. Assume steam of 150-lb. gage pressure, say, 165 lb. absolute, superheated 400 deg. F., or to a total temperature of 766 deg. F.; to be worked to a vacuum of 28 in., or 1 lb. absolute. To make a pound of such steam from feed water at the temperature corresponding to the lower pressure, 101.83 deg. F., requires 1330.3 B.t.u., of which, if the steam were expanded adiabatically to the lower pressure, 413.53 would be converted into work, and 916.77 voided to the condenser. There would therefore be 31 per cent. of the heat converted to mechanical energy by an engine of 100 per cent. efficiency.

In Fig. 1, where vertical distances represent absolute temperatures, start at *A* with a pound of water as it comes from the hotwell at 101.83 deg., and raise its temperature to 366 deg. F., or 825.6 absolute corresponding to 165 lb. the absolute initial pressure. If the horizontal distances are made such that the area under the curve is proportional to the heat that has been put into the water at any instant, the temperature will rise along the line *AB*, and the area *ABCD* will represent the amount of heat necessary to raise a pound of water from 101.83 to the boiler temperature 366 deg. At *B* the water commences to boil and absorbs heat at the constant temperature 366 deg. F., and the line of constant pressure *BE* is made of such length that the area *BEGC* is proportional to the heat absorbed in evaporating it, the latent heat of the steam tables.

If the application of heat is continued after the water is all evaporated, the temperature of the steam will rise along the line *EH*, and the area *EHIG* is proportional to the amount of heat required to superheat it 400 deg. F. or to 766 deg. F. If, now, it is allowed to expand without receiving or giving up any heat, except that converted into work, its temperature will drop along the line *HI*, and when this temperature has reached the lower limit, 101.83 deg. F., represented by the height of the line *IJ*, an amount of heat proportional to the area *ABEHJA*, will have been converted into work, and the rest, equivalent to the area *AJID* will be rejected to the condenser. In this case, the total heat supplied 1330.3 B.t.u. is represented by the area *ABEHIDA* of which 413.53 B.t.u. represented by the area *ABEHJA*, or 31 per cent., is converted into energy by an engine of 100 per cent. efficiency, working on the Rankine cycle between these limits.

If, now, instead of allowing the steam to cool off, as it expanded, heat were added to it at a rate that would keep its temperature constant up to a point as *K*, and then the steam were allowed to expand adiabatically to *L*, heat proportional to the area *HKLJ* would be added to the convertible portion at the cost of adding heat proportional to *HKMI* to the whole, and it is evident that the area gained is a considerably greater proportion of that added than is the convertible area *ABEHJA* of the previous diagram (*ABEHIDA*). (In fact, to bear the same proportion, the convertible area of the original diagram would have to fill the rectangle *ANIJ*.) To do this would take an amount of heat proportional to the area *HKMI*, or 241.3 B.t.u., making the total heat represented by the diagram *ABEHKMDA* 1571.6 B.t.u., of which that represented by the area above the line *AL* would be convertible. This would be 544.3 B.t.u., or about 34.6 per cent.

This could be done only if heat could be poured into the steam as it was expanding, as by heat communicated through the blades or other inclosing surfaces, and by ceasing this heating when it was desired to change the expansion from the isothermal *HK* to the adiabatic *KL*. This would be impracticable, and Ferranti, not being able to get the whole loaf, goes after half of it. He allows the steam to expand adiabatically on the line *HI* in the diagram, say, to *O*, where it will have a pressure of 29

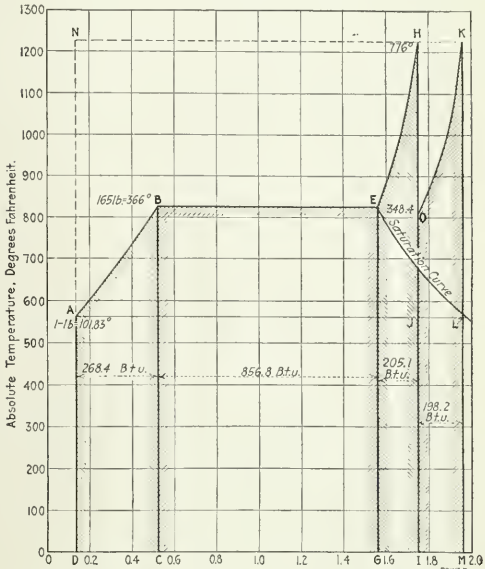

Fig. 1. Heat Relations in Ferranti Turbine

lb. and 100 deg. of superheat, and be at a temperature of 348.4 deg. F. He then passes it through a reheater, bringing it back to the initial temperature (766 in our assumed case), but at the reduced pressure. The temperature will rise along the line *OK*, and the heat added by the reheater will be proportional to the area *OKMI*, of which that represented by the area *OKLJ* is convertible. The steam then expands adiabatically along the line *KL* to the lower temperature limit. The diagram shows that it would have crossed the saturation curve at this point, but in the actual turbine, due to the taking up of heat from the jacketed casing, the steam is still superheated as it passes to the condenser or to the feed-water heater which precedes it.

The heat required for the final superheating for the supposed condition would be 198.2 B.t.u., making the total heat supplied

	B.t.u.
Heat of the liquid	268.4
Heat of evaporation	856.8
Superheating	205.1
Reheating	198.2
Total	1528.5

Of this 501.2, or 32.8 per cent., is convertible into energy in the two stages. This represents an improvement

n efficiency of 1.72, which is a gain of 5.5 per cent. over hat of the former or usual cycle.

If the reheating could be continuous, the efficiency could be still further improved, as has been shown above. The more times the steam could be reheated in passing through the turbine, the nearer this condition would be pproached, but loss of pressure head through the reheat-

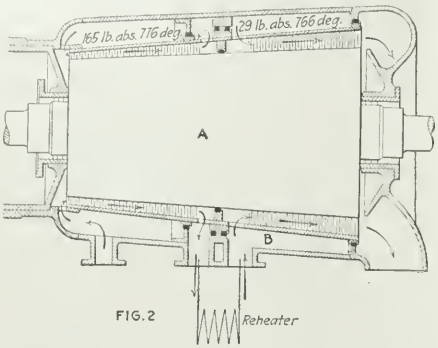

FIG. 2

Longitudinal Section of Ferranti Turbine

rs, and other practical considerations would limit the number of times that this could be done with advantage. n the experimental turbine only a single reheating stage s used.

In addition to the theoretical gain in efficiency offered y this cycle it presents the advantage of eliminating noisture from the turbine. As is well known, the first ew degrees of superheat improve the actual performance f a turbine considerably more than can be accounted for n a heat-unit basis, presumably because of the elimination of the braking effect of moisture upon the swiftly evolving parts, and of the fact that a considerably less veight of superheated than of saturated steam will leak hrough a given aperture under a given pressure. The rosive action of the moisture is also avoided when, as n the Ferranti turbine, the steam is superheated throughut its passage.

The Ferranti Turbine

The use of steam of such high temperature involves, nowever, a turbine especially designed to avoid the stresses nd distortion which such temperature ranges involve. 'ast iron is totally unadapted for such use, as experience vith growing pipe fittings and distorted turbine diabhragms has demonstrated. The Ferranti turbine is herefore made entirely of wrought metal; even the exerior casing is of boiler plate. The movable blades, of he Parsons or reaction type, are carried upon a steel drum not stepped in various diameters as in the usual onstruction, but of a continuous taper as at *A* in Fig. 2. Surrounding this drum and carrying the stationary blades s another symmetrical cylinder or cone *B* made of boiler teel.

The blades have a tough steel core with a covering of nickel electrically welded on. About the steel blade, already fashioned to the correct section, is wrapped a sheet of nickel some $^1/_{64}$ of an inch in thickness. The whole is heated electrically to a welding heat and rolled while hot hrough rollers which unite the metals so thoroughly that they do not part even when the blade is twisted, tortured, and bent into any conceivable shape. The coefficient of expansion of the metals is identical, and there is no electrolytic action between them.

At the base of each blade two tiny projections are left, the blade is accurately spotted to its place upon the drum by an automatic machine and current turned on which melts the projections and electrically welds the blade in place, avoiding the distortion and irregular stresses which come from driving and calking blades into a drum cut up by grooves. This method of blading is in successful use not only in the experimental turbine but in the Russian cruiser "Catherine II" and a Turkish cruiser, each of 40,000 hp. The "Kongo," the "Kator," and another vessel now building in Japan, each with 80,000 hp., the highest powered vessels afloat, also have nickel-steel electrically welded blading in the impulse portion of their turbines.

The leading thought in the design is symmetry. No abrupt changes of shape, no irregular members, and the very symmetry that prevents distortion under wide variations of temperature permits closer radial clearances and further reduces the leakage losses. Depending upon this fixity of the relative position of the blades Ferranti equips each row of both rotor and stator with a shroud consisting, as shown in Fig. 3, of a thin strip of metal turned upward and inward at the sides and carrying a strip of graphite which protrudes above the sides of the carrier. The top surface can run very close to the surface of the drum or shell, for contact simply rubs down the graphite and produces automatically a minimum clearance with no danger of fusing or freezing on. The greater diameter made allowable by this close clearance has the advantage of greater peripheral velocity and a greater amount of energy abstracted by each row of blades, therefore a smaller number of stages for a given range of expansion.

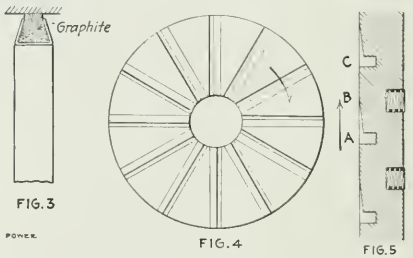

FIG. 3 FIG. 4 FIG. 5

Details of Ferranti Turbine

The number of rows or stages varies inversely as the square of the peripheral speed.

The question will naturally occur, what effect will such a superheat have on the dummy pistons? It would doubtless be very troublesome if there were dummy pistons, but there are none. No attempt is made to balance the end thrust, but it is taken up on a thrust bearing which is a modification of the Kingsbury block. Imagine a disk with radial grooves, as in Fig. 4, a development of the rim of which is shown exaggerated in Fig. 5, the surface from *A* to *B* being inclined at a slight angle to the base, while that from *B* to *C* is parallel. The grooves are filled with oil. A flat disk upon the shaft whose thrust is to be taken rides upon the surface *BC*, and turning in the di-

rection of the arrow entrains oil up the slight incline, forcing the disks apart. In pockets in the back of the disks, as shown, are springs stressed to some 20 per cent. above the normal pressure. A number of these members are used in series, and as the pressure induced by the entraining action of the disks on the oil increases it compresses the springs, increases the section through which the oil may pass, and distributes the load among the several blocks. The end thrust on the experimental turbine is some 80 tons, and the thrust blocks carry about 500 lb. per sq.in. Ordinary turbine oil is used, circulated and cooled in the usual way.

The cylinder which carries the stationary blading is supported concentrically with the bearing, and quite clear of the necessarily unsymmetrical outside casing. Between the cylinder and the casing are belts for steam of different pressures but of the same temperature. Steam admitted to the first chamber and surrounding the high-pressure end of the shell passes through the first portion of the blading, is drawn off at the point indicated, passed through the reheater, returned to the chamber surrounding the low-pressure part of the shell at the lower pressure, but at the initial temperature. Conduction from this shell, subjected throughout its length to the high initial temperature, tends to keep up the temperature of the steam all the way through the turbine. Packing rings carried on the symmetrical stator drum fit into grooves in the outer casing to separate the pressure chambers while permitting freedom of movement radially and longitudinally.

The experimental turbine has a capacity of 3000 kw. at 1500 r.p.m. It has only two bearings, and is 10 ft. 6 in. between bearing centers. It has produced current at the rate of a kilowatt-hour on 9.4 lb. of steam having an initial pressure of 130 lb., 680 deg. F. total temperature at entry to both high- and low-pressure stages, and with a vacuum of 28.7 in. referred to a 30-in. barometer. It is not possible to state just what efficiency this represents without knowing to what extent the steam was expanded in the first stage, and, therefore, how much heat was added to it in the reheater.

The Venturi Gate Valve

Another invention of Ferranti's which is just becoming known in America is his Venturi valve. Large valves are cumbersome and expensive, and many advantages attend the controlling of the flow of a fluid through a smaller orifice. Ferranti places the gate of his valve in the throat of a Venturi tube, which converts pressure temporarily into velocity, allowing a smaller passage to be used, and restores the pressure upon the "down stream" side. The uniform section of the neck is preserved by a ring drawn into place when the gate is lifted. See POWER, Sept. 24, 1912, p. 475.

A Long Look Ahead

In his inaugural address as president of the Institution of Electrical Engineers, Ferranti gave his imagination full sway in a broad consideration of the subject of coal utilization. If electrical energy could be sold at one-quarter of a cent per kilowatt-hour everybody would use it for all sorts of purposes. Heating would be done and manufacturing processes, such as smelting ore, steel making, etc., carried on by electricity instead of by promiscuous and wasteful coal burning.*

Well, if everybody would use it for such purposes it could be sold at that price, and Ferranti conceives for Great Britain a chain of 100 great central stations, each with 10 generators, turbine-driven, of course, of 25,000 kw. capacity each. The promiscuous demand, of which a large portion would be controllable as to time, would produce a load factor of 60 or more. The coal, instead of straggling over the country in thousands of minute streamlets at infinite cost in labor of handling, would flow in 100 lines in the most efficient manner directly to the 100 points of use, many of which would be contiguous to the mines. Instead of being burned in the present wasteful and inefficient manner, polluting the atmosphere with its smoke and gases, it would be converted in the most efficient way into gas, burned smokelessly as such, and the byproducts recovered, which would furnish fertilizer to enable the land by intensive cultivation to supply the country's food, 77 per cent. of which is now imported. He even hints at controlling the sunshine and the rainfall electrically, remarking that while such speculations may seem only mad visions of the future, they can hardly be considered more improbable than anyone would have considered wireless telegraphy or flight in heavier-than-air machines 50 years ago.

A Boiler-Room School

A school of instruction, for superintendents, engineers and boiler-room foremen, is to be established at the Peoria plant of the Illinois Traction System by Harrington & Peebles, Chicago, advisory engineers on boiler-room economy. The plan is to equip one boiler with a full set of both indicating and recording instruments to show and record draft and temperature changes that take place with different conditions and methods of firing. Both the coal and water will be continuously measured and a test may be conducted at a moment's notice.

It is intended to indicate to the engineers and firemen the value of different parts of the boiler, the most efficient methods of firing, the use of the various instruments necessary in detecting efficiency losses and the value of smokeless combustion, the effect on efficiency of soot and scale accumulations, the effect of various sizes and kinds of coal and the most efficient percentage of CO_2.

Not only will this be demonstrated on the test boiler, but when a condition of highest efficiency is obtained, it will immediately be applied to the rest of the plant and a practical demonstration made of the possibility of applying such a condition to any entire plant.

Mr. Chubbuck, vice-president of the Illinois Traction System, has shown progressiveness in thus establishing the first school of its kind in street-railway power plants.

Mr. Harrington was for many years the chief engineer of the Green Engineering Co., Chicago, and Mr. Peebles was his assistant in the engineering department of the same company.

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*Since writing the above a friend has called my attention to an acknowledgment in Rodenhauser's work on "Electric Furnaces in the Iron and Steel Industry," that Ferranti was first to recognize that by the use of the induction furnace we are able to obtain any desired current strength in the secondary circuit by properly winding the primary, and to use the idea in the design of an electric furnace, described in his patent in 1887. How many people were thinking about electric furnaces upon a large scale at that time?

Air-Compressor Installation and Operation

By E. M. Ivens

SYNOPSIS—The compressor is not the rough and ready machine imagined by some engineers. For efficient service and safe operation, it must be properly installed and given faithful attention. How to do this is simply told in the following article.

Unsatisfactory operation of air compressors and disastrous explosions in receivers and pipe lines emanate mostly from improper installation in the first place and continued negligent operation and disregard of the compressor manufacturer's instructions in the second place. Unfortunately, many operating engineers look upon the compressor as a rough and ready machine built to withstand all manner of abuse, expensive to operate, and only to be used when nothing else will serve the purpose. This impression is erroneous and is easily corrected if the intended operator, before erecting a compressor, will familiarize himself with the practical principles of air compression; the attendant dangers and necessary precautions; and the simple requirements essential to economical operation. A few instructions follow which if observed only indifferently will furnish the much needed relief to the compressor, as well as reduce operating costs and eliminate the danger of the now too frequent explosions.

Location

In installing a new compressor, the first consideration is where to build the foundation. The cleanest and coolest place available in the room should be chosen, and ample space provided all around so that cleaning and inspection of the compressor may be easily accomplished. Location in boiler rooms and near coal piles, which is so often done, should be especially avoided.

Foundation

To appreciate the value of a good foundation, consider the exacting and severe duty that the compressor is required to perform. The earliest type of dry compressor and the one in most general use at present is the straight-line steam-actuated machine. The principle is simply the direct application of power to resistance by the use of tandem pistons and extended rod.

Fig. 1. Diagrams from Straight-Line Compressor; Power Maximum, Compression Minimum

Referring to Figs. 1 and 2, the pressure relations are as follows: During the first part of the stroke the energy in the steam cylinder is at its greatest, while in the air cylinder compression is just beginning, and consequently the resistance is least. As the pistons advance, the steam and air pressures approach a balance until at some point past mid-stroke power and resistance are exactly equal. After this neutral point is past, the ratio of power to resistance then decreases until finally at the end of the stroke, the former is minimum, and the latter is maximum. The excess of power in the steam cylinder at the beginning of the stroke is stored up in the flywheels, increasing their momentum, and is returned to the shaft during the latter part of the stroke, helping the machine over each dead center.

The duplex type of compressor is, in effect, two straight-line compressors placed side by side, and connected by a common crankshaft on which is mounted the balance wheel. The crank of one side is set a quarter of a circle in advance of that of the other side so that when the pistons of one are at mid-stroke those of the other side are at the beginning or end of their stroke. Fig. 3 shows

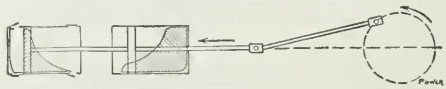


Fig. 2. Power Minimum and Compression Maximum

the steam pressures and opposed air pressures at the beginning of a revolution. Power is in excess of resistance in the upper set of cylinders, while in the lower cylinders the reverse exists. The surplus power in the upper steam cylinders is applied through the crankshaft to carry the lower half over the center.

Fig. 4 shows the instantaneous steam and air pressures a quarter of a revolution later. Here, power is in excess of resistance in the lower cylinders, and minimum power is opposed to maximum resistance in the upper cylinders. Assistance is now received by the upper half from the lower half by the transmission of the surplus power through the crankshaft as before.

A quarter of a revolution later, Fig. 5, the compressor has begun its return stroke, and the conditions are exactly the same as those shown in Fig. 3, but reverse in direction. Fig. 6 shows the conditions existing during the last part of the revolution which are identical with those shown in Fig. 4, but also reverse in direction.

Thus it can be readily seen that aside from the vibrations characteristic of all reciprocating machinery, the compressor is subjected to unbalanced shocks, and strains that are imposed by the nature of the duty and which also must be absorbed by the foundation. The size and depth of foundation depends largely upon the nature of the soil in which it is to be built. The manufacturers send out detailed foundation plans with each compressor, assuming, of course, that the foundation is to be built in reasonably firm ground, but if the ground is insecure, a liberal base a foot or more larger all around than the foundation bottom should be added to the manufacturer's specifications. It is important that special pains be taken to make the foundations for straight-line compressors of liberal size and rigidity, and it is a good plan to reinforce concrete foundations with ½- or ⅝-in. iron rods near the top and bottom, placing some lengthwise and others crosswise of the foundation. In the duplex type of compressor, the unbalanced strains are considerably less, but the same care should be taken in building the foundation.

Receiver

The functions of the air receiver are to create a cushion and thereby eliminate the pulsations in the pipe line, to

erve as a storage of power, to cool the air and precipitate ny oil or moisture carried in entrainment, and to elimiiate certain friction losses that would occur if cooling vere effected in the pipe lines. The receiver should conequently be located in a cool place, preferably outside of he building, and as close as possible to the compressor. Receiver fittings should include a pressure gage, safety alve and blowoff cock located at or near the bottom.

Air-Inlet Piping

An increase of 5 deg. F. in temperature of the intake ir is accompanied by a decrease of 1 per cent. in volumetric efficiency. This means that as intake-air temperaure increases, the free air capacity of the machine dereases, and the same amount of energy is expended as hough the full capacity of the machine were being ealized. To assist the compressor, then, the inlet should e piped to the outside of the building, and up some 10 r 12 ft. above the ground surface. The opening should e well screened to prevent drawing in dust and dirt and ooded to keep out rain. If it is impracticable to carry he intake outside and air must be drawn into the cylinler directly from the room, it is very important that no lust or dirt be allowed near the opening, for a small mount being continually drawn into the cylinder with he air will cut and wear the inner surfaces and valves ery rapidly, and no end of trouble results.

Sometimes conduits are used instead of piping to the nlet. These are best constructed of wood lined with tin nd the opening well screened. Concrete or brick conruction should be avoided, for grit is liable to be loosened y the vibrations of the compressor and drawn into the ylinder. Conduits should be of at least double the crossectional area of the inlet opening of the compressor.

As few bends as possible should be put in inlet piping, nd when used, should be either long-turn fittings or pipe eatly bent, preferably the latter. To further reduce rictional resistance the inlet piping should be increased n diameter in proportion to its length. A good rule to ollow is to increase the diameter ½ in. for each 10 ft. dded in length.

Discharge Piping

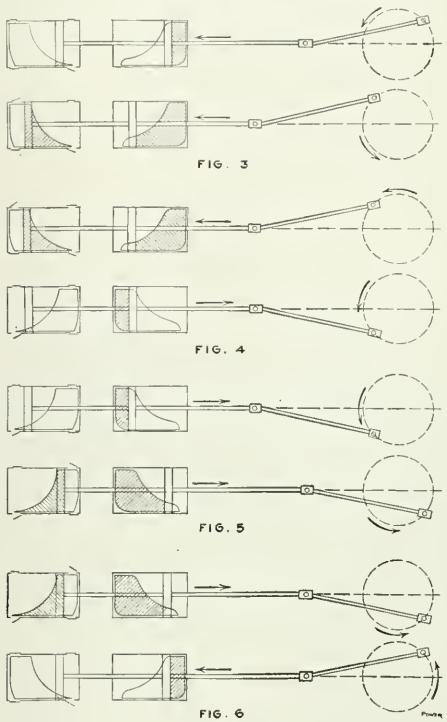
The pipe connecting the compressor and receiver should e of at least the diameter of the discharge opening of he cylinder and contain as few bends as possible. Very ften, a salesman in taking an order for an air receiver, ecommends one whose inlet opening is considerably maller than the compressor-discharge opening. When he receiver arrives, and the engineer on the ground learns his, he immediately proceeds to insert a pyramid of bushngs in the cylinder opening. This imposes additional ardship on the compressor and creates a condition conucive to an explosion.

Another serious mistake that is often made is the placng of a stop valve between the compressor and receiver. This should never be done unless a safety valve is placed etween the stop valve and the air cylinder, for there is possibility of at some time starting up with the stop alve closed when a dangerous pressure will soon be eached and an explosion is likely to occur.

Lubrication

The bearings and other external wearing parts of the ir compressor are usually lubricated either by means of il and grease cups suitably placed, or by a splash or bath system. The latter method is coming into more popular favor and is rapidly replacing the former because of its simplicity, effectiveness and economy in the use of oil. Against it stands the objection that it is likely to be neglected and the oil allowed to become dirty and gritty, due to accumulation of abrasives gathered by the oil in passing and repassing over the bearings.

Air-cylinder lubrication is by far the most vital point in air-compressor operation, and it seems to be the least understood. In order to fully appreciate the necessity of proper cylinder lubrication, consider the conditions that have to be met. The compression of a gas is accompanied



Duplex Compressor Diagrams, Showing Relative Relations between Power and Compression

by a rise in temperature in accordance with the well known law of thermodynamics. The temperature of the air at discharge from the cylinder is dependent upon not only the pressure but upon the temperature of the intake air as well. Assume that a single-stage compressor is operating at sea level, that the atmospheric temperature is 60 deg. F. and the discharge pressure is 70 lb., the final temperature of the air will be 866 deg. abs. or 406 deg. by the thermometer. This calculation is based on no heat radiation losses and is consequently slightly greater than the actual discharge temperature. The difference between actual discharge temperature and that calculated above is small, for the actual compression line follows the adiabatic very closely. Air is one of the poorest conductors of heat and the water jacket has little effect other than facilitating lubrication. Tests of compressors operating under conditions named show that the actual

discharge air temperatures range between 325 and 365 deg. F. and instances of even higher are on record.

The lowest temperature at which an oil will give off combustible vapors is called the flash point and the temperature at which these vapors ignite and continue to burn, is the ignition point. The flash point of common lubricating oil is about 260 deg. F., and the ignition point about 295 deg. Common cylinder oils flash at about 350 deg. and ignite at about 400 deg. F. The oil best suitable to air-cylinder service is one having a flash point of about 500 deg. and an ignition point of about 600 deg. F.

If proper oil is used, a comparison of temperatures will show that under ordinary conditions and with cylinder and valves in good condition, an explosion is impossible. If, on the other hand, a low-flash-test cylinder oil is used, it is soon decomposed by the heat and the volatile constituents are ignited and a destructive explosion usually follows. There are instances on record where ignition has occurred without explosion, but the chances are always in favor of explosion.

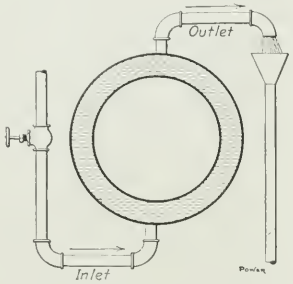


Fig. 7. Piping to Cylinder Water Jacket

A scored cylinder and valves caused by dirt and grit drawn in with the air and sticking discharge valves may also cause the ignition of volatile constituents of the oil. For instance, suppose that a sufficient amount of air at discharge temperature found its way back from the receiver or pipe line into the cylinder on the suction side of the piston, to raise the initial temperature from 60 to 200 deg. F. This air might return either through leaky or sticking discharge valves, or from the compressing side of the moving piston to the suction side. Then with 200 deg. F. initial temperature, the final temperature of air compressed to 70 lb. gage would be 635 deg. F., which is high enough to decompose and ignite even the best of oils. This shows the importance of locating the compressor so that the coolest and cleanest air obtainable is drawn into the cylinder. Other conditions which are favorable to ignition are carbon deposits from the oil on the valves and passages restricting their area; too small a discharge pipe; and drawing air from a hot engine room. Any of these cause at least an increased final temperature, and each, if extreme, will ultimately cause ignition.

Only a very small amount of oil is necessary for the air cylinder and as little as possible should be used, for excess of oil will deposit carbon and gum the valves. Just how much can best be determined by experiment, but a good approximation is one drop per minute for cylinders of from 6- to 10-in. stroke, three drops in two minutes for cylinders of from 12- to 16-in. stroke, two drops per minute in cylinders of from 18- to 24-in. stroke, and three to five drops for larger cylinders. These quantities apply when the compressor is running at normal speed, and if for any reason the revolutions are increased or decreased, the quantity of oil should also be varied in proportion.

Circulating Water

The duty of the jacket water is to carry off the heat transmitted to the cylinder walls and heads by the compression of the air, and thereby assist lubrication. A liberal supply of cool water should be furnished the jacket and necessary precautions taken that will prevent starting up with a dry jacket. Air cylinders are provided with water-inlet and outlet openings as well as a drain. In some cylinders, inlet and outlet openings are at the top of the barrel while in others, the inlet is below and the outlet above the barrel. In the first instance, there can be no mistake in making pipe connections, but with the latter arrangement of openings, the error is often made of connecting the inlet pipe above into the outlet opening. When this error is made, the jacket is not kept full of water, and the surfaces not in contact with the water will become heated.

The water outlet should be in plain view of the operator and this is best accomplished by allowing the water to fall into an open-pipe end or funnel, as shown in Fig. 7. The controlling valve should always be placed in the inlet. Sometimes the circulating water is used for other purposes after leaving the jacket, and a closed circuit is necessary. The jacket-water pressure should not exceed 50 to 60 lb. unless special attention has been given to the design. Dirty circulating water is injurious in that mud deposits will form which prevent the water from reaching the metal and heating will result. If the compressor is exposed to freezing temperature, the jacket should be drained after shutdown; otherwise the expansion of the water in freezing will crack the jacket.

Inspection and Cleaning

At stated intervals, say, every month, the compressor should be thoroughly inspected and any defect corrected immediately. The air valves of the modern compressor are usually placed conveniently and can be easily removed and examined. They should present an oily surface and be kept free of carbonaceous deposits. The ports and passages should also be kept clean and free from obstructions.

Cleaning of the inside of the air cylinder may be done effectively by filling the lubricator with a strong solution of water and soap, and feeding liberally throughout a day's run. Liberal quantities are necessary because soap in itself is not a very good lubricant. At the end of the day's run the lubricator should be filled with oil and the compressor operated for awhile. This to prevent rusting of the inner polished surfaces. Because of its low flash point, kerosene should never be used for cleaning the cylinder.

Summing up all that has been said, the following mode of operation is obviously to be recommended:

Every morning—Drain the receiver; notice the height of lubricating oil in the crank case or in the oil cups and replenish if necessary; adjust the lubricator for the proper amount of oil feed; start the circulating water.

Every week—Remove the crank-case oil and filter it;

remove and examine the suction and discharge valves, if worn or cut, they should be ground to a tight fit; test the safety valve by raising the air pressure to the point of blowoff; take up lost motion in the pins and bearings.

Every month—Renew the crank-case oil and thoroughly cleanse the inside of the crank case; thoroughly inspect all parts, including the air and water passages.

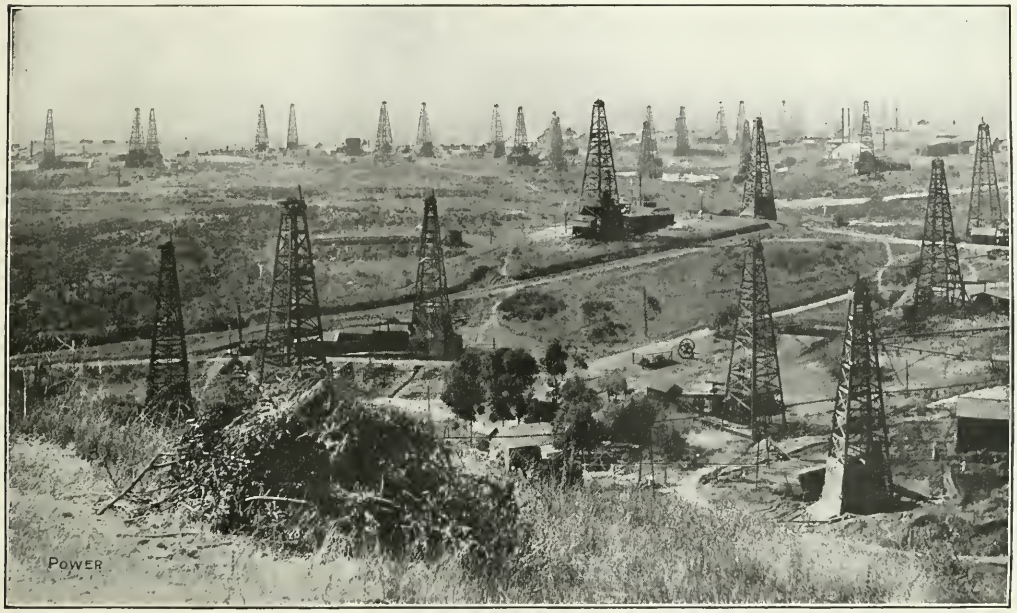
Like any other piece of machinery, the air compressor will need thorough overhauling at some time. The parts most likely to break are the valves and it is advisable to carry on hand a complete set of both inlet and discharge valves for emergency and thus avoid expensive shutdowns while waiting for new ones from the factory, or else operating with a badly worn or broken valve.

The World's Fuel-Oil Production

By J. J. McIntosh

SYNOPSIS—Uses of fuel oil and comparative productive records of different countries.

A review of the progress of petroleum development shows that in the early stages of this industry, discoveries of oil deposits were, in a large measure, controlled by chance. In some oil fields the discovery followed the investigation of seepages, while in others the presence of oil was discovered while drilling for water or the presence of gas led to investigation. Owing to the vastly superior knowledge, in the matter of oil-bearing formations, which we now possess, the element of chance is eliminated and we are able to systematically trace oil-bearing strata under large areas. The enterprise and diligence of the United States Geological Survey in its work of investigating local geological conditions has been chiefly instrumental in bringing this about.



Oil Fields of Southern California

The use of oil fuel on the railroads and in the United States navy and merchant marine service is rapidly increasing. The transcontinental railroads are now using oil fuel on many miles of line. Some of the railroads in the northwestern part of the United States and in southern Canada held to coal for a considerable period after the permanency of the fuel-oil supply was assured. The last tie to coal became broken with the realization that the failure of their immense locomotives to move the weight that had been confidentially expected of them, was not the fault of the machines. The weight of trains over the mountain divisions was invariably limited to the endurance of the fireman. Shoveling coal on the large engines over these divisions is a task that few can stand up to. With the use of oil as fuel this feature was entirely removed.

The United States navy has some 20 oil-burning torpedo-boat destroyers, and eight battleships which burn oil as auxiliary to coal. The battleships "Nevada" and "Oklahoma" burn oil exclusively.

An event of interest in the merchant marine service was the voyage of the "Honolulan" from Baltimore, Md., to Seattle, Wash. This vessel carried a cargo of 7000 tons of coal but was propelled by oil. The journey covered 14,000 miles and required a barrel (42 gal.) of oil per

le. The oil weighed 1866 short tons, and to serve the ne purpose it is estimated that 5600 tons of coal would ve been needed.

Production Data

A glance at Table 1 shows the world's total production 1911 to be 345,512,185 bbl., or over 46,500,000 metric

United States for 1911 is of interest. Tables 1 to 4 inclusive, were compiled by the United States Geological Survey.

In regards to the oil production in Mexico, the United States Geological Survey reports as follows: "The quantity of oil which the Mexico fields are now ready to furnish is variously estimated at from 6,000,000 to 12,000,-

TABLE 1. WORLD'S PRODUCTION OF CRUDE PETROLEUM, 1906-1911, BY COUNTRIES, IN BARRELS AND METRIC TONS

Country	1907	1908	1909	1910	Rank	1911 Barrels	1911 Metric Tons	1911 Per Cent. of Total Production
ted States	166,095,335	178,527,355	183,170,874	209,557,248	1	220,449,391	29,393,252	63.80
sia	61,850,734	62,186,447	65,970,350	70,336,574	2	66,183,691	9,066,259	19.16
ico	1,000,000	3,481,410	2,488,742	3,332,807	3	14,051,643	1,873,552	4.07
ch East Indies	9,982,597	10,283,357	11,041,852	11,030,620	4	12,172,949	1,670,668	3.52
mania	8,118,207	8,252,157	9,327,278	9,723,806	5	11,101,878	1,544,072	3.21
icia	8,455,841	12,612,295	14,932,799	12,673,688	6	10,485,726	1,458,275	3.04
ia	4,344,162	5,047,038	6,676,517	6,137,990	7	6,451,203	897,184	1.87
an	2,010,639	2,070,145	1,889,563	1,930,661	8	1,658,903	221,187	0.48
u	756,226	1,011,180	1,316,118	1,330,105	9	1,398,036	186,405	0.40
many	756,631	1,009,278	1,018,837	1,032,522	10	995,764	140,000	0.29
ada	788,872	527,987	420,755	315,895	11	291,096	38,813	0.08
y	59,875	50,966	42,388	42,388	12	a71,905	10,000	0.02
er	a30,000	a30,000	a30,000	a30,000	..	a200,000	26,667	0.06
Total	264,249,119	285,089,615	298,326,073	327,474,304		345,512,185	46,526,334	100.00

a Estimated.

ns. The United States ranks first in the production petroleum, producing 63.8 per cent. of the world's al output. Table 2 gives the total quantity and value petroleum produced in the United States and the avge price per barrel in 1910 and 1911, by states, in bars. Table 3 gives the percentage of increase or decrease, the different states in 1910 as compared with 1911.

000 bbl. a month. The total production was perhaps a tenth as much, the production being limited neither by supply or demand, but by transportation facilities. The needed tank steamers are being furnished as rapidly as they can be built. It should be borne in mind, however, that, given a supply of tank steamers sufficient for all the oil that can now be furnished for the Eastern coast,

TABLE 2. TOTAL QUANTITY AND VALUE OF PETROLEUM PRODUCED IN THE UNITED STATES AND THE AVERAGE PRICE PER BARREL IN 1910 AND 1911, BY STATES, IN BARRELS

State	1910 Quantity	1910 Value	1910 Average Price per Barrel	1911 Quantity	1911 Value	1911 Average Price per Barrel
ifornia	73,010,560	$35,749,473	$0.490	81,134,391	$38,719,080	$0.477
orado	239,794	243,402	1.015	226,926	228,104	1.005
nois	33,143,352	19,669,383	0.593	31,317,038	19,734,339	0.630
iana	2,159,725	1,568,475	0.726	1,695,289	1,228,835	0.740
nsas	1,128,668	444,763	0.394	1,278,819	608,756	0.476
ntucky	468,774	324,684	0.693	472,458	328,614	0.696
isiana	6,841,395	3,574,069	0.522	10,720,420	5,668,814	0.529
higan	3,615	4,794	1.326	7,995	7,995	1.000
ssouri						
w York	1,053,838	1,414,668	1.342	952,515	1,248,950	1.311
o	9,916,370	10,651,568	1.074	8,817,112	9,479,542	1.075
ahoma	52,028,718	19,922,660	0.383	56,069,637	26,451,767	0.472
nsylvania	8,794,662	11,908,914	1.354	8,248,158	10,894,074	1.321
xas	8,899,266	6,605,755	0.742	9,526,474	6,554,552	0.688
h	115,430	93,536	0.810	186,695	124,037	0.664
oming						
st Virginia	11,753,071	15,723,544	1.338	9,795,464	12,767,293	1.303
Total	209,557,248	$127,899,688	$0.610	220,449,391	$134,044,752	$0.608

lifornia ranks first with a production of 81,134,391 l. in 1911 to her credit. Oklahoma ranks second with production of 56,069,637. In 1912 the production of troleum in Oklahoma declined to about 52,000,000 bbl. nile the California output for the same year increased about 87,000,000 bbl. Referring to Table 3, the total crease in the United States in 1911 over that of 1910 5.20 per cent. Table 4, giving the well record in the

the market would probably be temporarily oversupplied. The consumers of fuel require time for the substitution of oil for coal, though the many advantages of the former are obvious."

Another factor in the future production of petroleum that is worthy of consideration will be the opening of the Panama Canal. This, in all probability, will be the means of opening up oil lands in Mexico and South America,

BLE 3. TOTAL PRODUCTION OF PETROLEUM AND PERCENTAGE OF INCREASE OR DECREASE BY STATES, IN 1911, AS COMPARED WITH 1910, IN BARRELS

State	Production 1910	Production 1911	Increase	Decrease	Percentage Increase	Percentage Decrease
lifornia	73,010,560	81,134,391	8,123,831		11.13	
lorado	239,794	226,926		12,868		5.37
nois	33,143,362	31,317,038		1,826,324		5.51
liana	2,159,725	1,695,289		464,436		21.50
nsas	1,128,668	1,278,819	150,151		13.30	
ntucky	468,774	472,458	3,684		0.0078	
isiana	6,841,395	10,720,420	3,879,025		56.70	
higan	3,615	7,995	4,380		121.2	
w York	1,053,838	952,515		101,323		9.61
io	9,916,370	8,817,112		1,099,258		10.98
lahoma	52,028,718	56,069,637	4,040,919		7.77	
nsylvania	8,794,662	8,248,158		546,504		6.21
xas	8,899,266	9,526,474	627,208		7.05	
ah	115,430	186,695	71,265		61.74	
oming						
st Virginia	11,753,071	9,795,464		1,957,607		16.66
Total	209,557,248	220,449,391	10,892,143		5.20	

TABLE 4. NUMBER OF WELLS AND DAILY PRODUCTION

Field	Wells Completed Oil	Gas	Dry	Total	Initial Daily Production, in Barrels Total	Average per Well
Appalachian	2978	976	1060	5,014	28,100	9 44
Pennsylvania and New York	1491	219	297	2,007	4,912	3 29
Central and southeastern Ohio	765	403	512	1,680	10,923	14 28
West Virginia	622	351	218	1,191	10,443	16 79
Kentucky	100	3	33	136	1,822	18 22
Lima-Indiana	554	23	67	644	7,477	13 50
Lima, Ohio	480	15	32	527	6,381	13 29
Indiana	74	8	35	117	1,096	14.81
Illinois	1061	41	263	1,365	66,851	63 01
Mid-Continent	3796	490	686	4,972	453,907	119.58
Kansas	172	150	96	418	3,271	19.01
Oklahoma	3294	304	489	4,087	262,333	79.64
Northern Texas	84	4	38	126	19,180	228.33
Caddoa	246	32	63	341	169,123	687 19
Gulf	415	50	149	614	106,885	257 55
Costal Texas	352	33	117	502	32,740	93.01
Costal Louisiana	63	17	32	112	74,145	1,176.90
California	963	.....	104	1,067		
Colorado	14	....	18	32		
Wyoming and Utah	37	.....	16	53		
Total	9818	1580	2363	13,761		

a Includes Marion County, Tex.

and thus a supply of oil will be made available for replacing coal to a considerable extent along the Atlantic seaboard, and in some of the Eastern states.

Out of the total production of petroleum in the United States for 1912, about 75,000,000 bbl. was used for fuel. Of this amount, probably two-thirds used was the crude oil, while the remaining was in the form of residues after the light distillates were taken off. The residues from the petroleum found in the Eastern fields is not used as fuel, it being valuable for manufacture into lubricants, paraffin wax, etc.

Although this amount is only a little over one-third of the total production in the United States, it must be remembered that a considerable portion of the amount produced went into stocks. In California alone the stocks amount to approximately 45,000,000 bbl. From this it is evident that a considerable portion of the oil produced was used as fuel.

Some Troubles of High-Speed Belt Drives

By James A. Seager

SYNOPSIS—By carrying a motor on a spring support above the floor the jerky action of a high-speed drive is eliminated. A simple arrangement of two idler pulleys on an adjustable link-frame support enables the belt to make the required arc of contact even at very high speeds.

A motor can often be applied in a position where a piece of line shafting cannot be conveniently located, but there are times when a motor-drive installation plan requires considerable thought to get best results. It may, therefore, be interesting to refer to one such instance in connection with the motor-drive scheme in a cabinet maker's shop and sawmill.

The excellent plan of placing the machinery itself on a false floor elevated some 4 or 5 ft. above the ground floor of the building was adopted, so as to place the electric motors underneath the working floor of the factory and also to provide accommodation for a system of shaving and dust removal. The advantage of this system of installation is obvious, as both head room and floor room are saved by putting the motors below the machines and having nothing but a short length of belt coming into the working room.

In connection with one of the machines, however, a large four-cutter molding machine, some difficulty was experienced in getting satisfactory operation, owing to the arrangement shown in Fig. 1 being adopted. Owing to the short length of the belt, the high speed at which it traveled and its vertical position it was extremely difficult to keep it from slipping as it stretched. Much trouble, therefore, was occasioned by taking up the belt from time to time and finally the arrangement shown in Fig. 2 was devised.

The ends of two pieces of bar iron A of flat section were heated and while red hot, bent over a round bar so as to form an eye B. The bars were then bent into the position shown and a 1-in. hole drilled at C. The two bars pivoted at B were then placed under the base plate of the motor so as to lie centrally with the bolt holes in the base and corresponding holes were drilled in the bars, the base being then bolted up to the bars so as to tightly secure them.

Four angle pieces D to support the bars were fixed to the floor. A bar was also passed through the angle irons at the right, and upon this bar were placed two threaded bolts, each ¾ in. in diameter and having at the lower end an eye which slipped over the bar just mentioned. These bolts were fitted with nuts and washers and a spiral spring capable of resisting strong compression.

The motor was thus hung on two spiral springs, the weight of the motor being balanced by the compression on the springs. By tightening or slackening the lower nuts the springs could be compressed or extended so as to give the weight of the motor more effect and thus raise or lower it in position. After the belt was put on, the lower bolts were slackened until a sufficient tension was given to the belt. The elastic nature of the suspension frame provided against the sudden jerks which inevitably occur in a molding machine when the work is put into the cutters, and for this reason the arrangement may be recom-

mended to any factory engineer who finds trouble owing to short, jerky drives.

Difficulty has often been experienced in arranging and running and electric motor drive for high-speed woodworking tools, owing to both the motor and the machine spindles running at high speed. With small pulleys there is usually much slipping when running at high speeds. Sometimes, after the proper size of pulley and the proper width of belt has been used to transmit a given power, the belt, for some reason, slips badly, and the power cannot be obtained. The reason for this is twofold. In the first place, with high belt velocities there is a tendency for the belt to carry with it on its under surface, between the belt and the pulley, a thin layer of air which de-

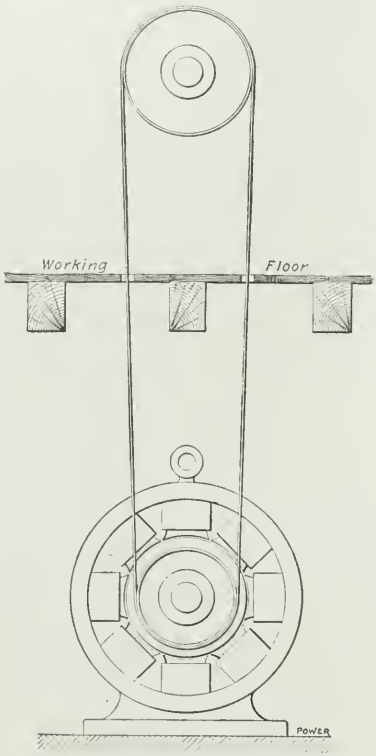


Fig. 1. Motor Drive from below Floor

stroys the adhesion and hence prevents the transmission of power. So serious is this evil that in many cases it has become advisable to drill holes in the faces of the pulleys fairly close together to provide air vents so that air carried under by the belt can be squeezed out. This expedient will often increase the power transmitted at high speeds.

There is another trouble with high-speed transmissions, however, that cannot be so easily overcome. This is owing to the centrifugal force of the belt which exerts a stretching action and tends to make it run in a straight line instead of around the pulley. This action, exaggerated, is shown in Fig. 3. The result of this is that while the belt is at rest there is sufficient arc of contact on the pulley surface, but when the belt is in action this arc tends to diminish, until at very high speeds it decreases so much that there is loss of power.

A good arrangement to overcome this difficulty is shown in Fig. 4. Just above the lower pulley and on each side of it are two idler pulleys on pivoted arms held by a frame or supported on the floor so that the arms are parallel to one another. The two free ends of the pivoted arms *A* are held together by two eye-bolts *B* with right and left threads respectively, the eyes being slipped over projections on the pivoted rods. The screwed ends of these eye-bolts are connected by a right- and left-handed muff coupling, so that by turning the coupling the idler pulleys may be drawn in toward each other or allowed to move outwards.

When the belt is in position it bears on both pulleys and will move them, owing to the flexible nature of the arrangement, so that the bearing pressure of each pulley on the belt is equal to that on the other and this condition will maintain itself whether the belt is running or at a standstill; i.e., the belt will be controlled by the position of the idler pulleys. The bending tendency due to centrifugal force, shown in Fig. 3, only occurs

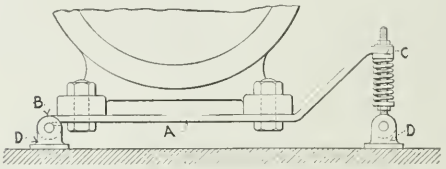


Fig. 2

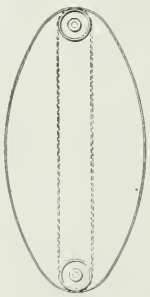


Fig. 3

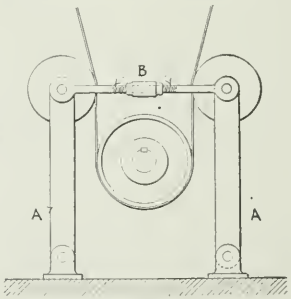


Fig. 4

Fig. 2. Spring Support for Motor

Fig. 3. How Belts Tend to Act at High Speeds

Fig. 4. Pivoted, Adjustable Idler

when the belt has left the surface of the idler pulleys. This arrangement will give a very powerful grip, and it has been found that by the addition of this simple device, the power transmitted by a given arrangement of belts and pulleys can often be largely augmented.

Isolated Plant Lights Owenton, Ky.—The city of Owenton, Ky., which was dependent upon the moon for its lighting, has granted a twenty-year franchise and a five-year contract to W. E. Arnold, of that city. Mr. Arnold, says "The Isolated Plant," owns and operates a large flour mill in Owenton, and his power plant is sufficiently large to easily carry this extra load.

ELECTRICAL DEPARTMENT

Induction Regulators

By John A. Randolph

This class of apparatus is used only on alternating-current circuits, its function being to maintain a constant voltage on feeders and rotary converters. There are two general types, the single-phase and the polyphase. In both there is a primary and a secondary winding, one of which is placed upon a movable iron core, while the other is wound upon a stationary core. Either winding may be made the movable element, but the general practice is to place the primary in this position. The primary windings of both the single-phase and the polyphase types are shunted directly across the alternating-current supply mains while the secondaries are connected in series with the respective lines or legs of the system.

The Single-Phase Regulator

This type is generally constructed as shown in Fig. 1. The primary winding is mounted on the movable core and is connected as a shunt circuit directly across the feeder mains. The secondary is placed in slots on the inside face of the stator or stationary core and is connected directly in series with the load. Each winding is so arranged that when in operation it produces an alternating magnetic flux with two opposite poles. The various positions of the poles of the movable primary winding, with respect to those of the stationary secondary, determine the action of the regulator. When the magnetic axes of the two windings coincide, the primary is at either a maximum boost or a maximum lower position, depending upon whether similar or dissimilar poles are opposite each other in position. These conditions can be analyzed by reference to Fig. 2. Let PP represent the magnetic axis of the primary and SS that of the secondary. In the condition shown, the two axes coincide. It therefore is apparent that the primary field may be made to either coincide in direction with that of the secondary or to directly oppose it by revolving the primary coil through an arc of 180 deg. When axis PP of the primary coil is revolved to a position at right angles to the axis SS, or midway between the maximum boost and the maximum lower positions, as shown in Fig. 3, the primary field will exert no inductive effect whatever on the secondary winding. This point is therefore known as the zero or "no-boost no-lower" position. The change in the effect of the primary on the secondary takes place gradually as the primary is rotated through the 180 deg. between the maximum boost and the maximum lower positions.

The short-circuiting coil, shown in Figs. 1, 2 and 3, is for the purpose of neutralizing the self-inductive effect of the secondary coil when the primary is at intermediate positions between its extremes and especially when it occupies the zero position. Let the conditions be con-

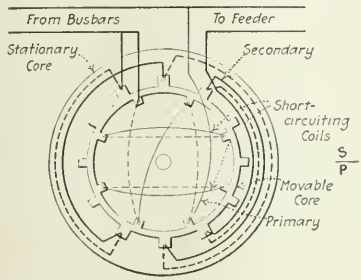


Fig. 1.

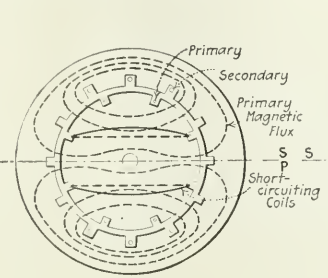


Fig. 2.

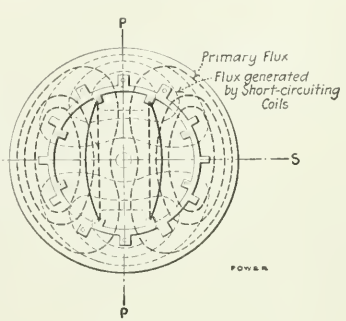


Fig. 3.

Induction Regulator Represented Diagrammatically in Different Positions

tacted when the primary is at the zero point, as shown in Fig. 3. At this point the primary has no effect on the secondary. The magnetic field of the secondary is therefore free to pass unrestrained through the primary core. If there were no field to oppose this action of the secondary flux, a heavy electromotive force of self-induction would result which would greatly reduce the active effect of the line potential. The short-circuiting coils are for the purpose of establishing a field which will neutralize the self-inductive tendency of the secondary. They consist of closed coils of wire placed at right angles to the primary coil. By virtue of their position they are inactive when the primary is at its extreme points, owing

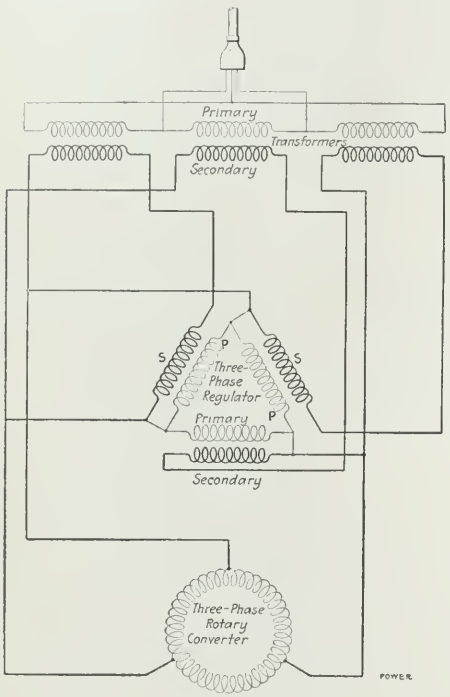


Fig. 4. Induction Regulator Connected to Three-Phase Rotary Converter

to the fact that their magnetic axis is perpendicular to the magnetic axes of the two main windings. However, as the primary is moved, the short-circuiting coils are brought gradually into positions where their conductors cut the secondary flux, a current being thereby induced in the short-circuiting coils. This current is at a maximum in the zero position of the primary and, being induced by the secondary field, the magnetic flux of the short-circuiting coils opposes that of the secondary and therefore neutralizes the self-inductive action of the latter.

The magnetic field of these coils in their position of greatest activity is shown in Fig. 3. Their general effect is the same as that produced by short-circuiting the secondary of a transformer. The sum of the ampere-turns of the primary and of the short-circuiting coils should be approximately equal to the ampere-turns of the secondary.

The movement of the primary winding is accomplished directly by hand through the agency of a crank or chain and sprocket; or it may be effected by a small motor controlled either at the regulator or at some point remote from it.

The Polyphase Regulator

The polyphase regulator, like the single-phase type, has two windings, namely, a primary and secondary one,

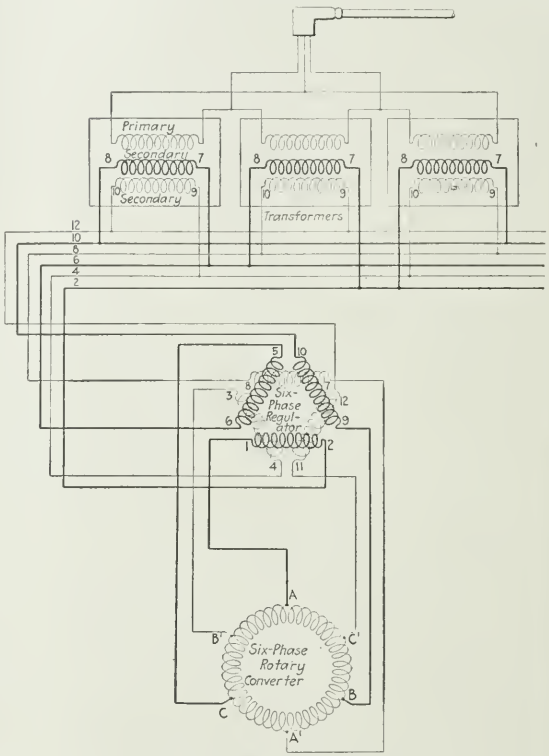


Fig. 5. Induction Regulator Connected to Six-Phase Rotary Converter

of which, generally the primary is mounted upon a movable core. The polyphase type, however, differs from the single-phase regulator in several important characteristics. One of these consists in the nature of its magnetic field which is rotating instead of alternating as in the single-phase type. Moreover, both its primary and secondary windings are composed of a number of independent windings corresponding to the number of phases in the supply circuit. To produce the rotating field the polyphase regulator is wound similarly to a polyphase induction motor. The speed of field rotation per pole for both primary and secondary windings is the same as that of the generator.

The regulation of the line voltage is accomplished by

varying the phase angle between the primary and secondary voltages by turning the movable winding through various angles. When a given pole of the primary is directly opposite a similar pole of the secondary, the voltage of the primary is opposite in phase to that of the secondary with the result that the voltage induced in the secondary is subtracted from the line voltage. As the movable coil is rotated away from the maximum lower position, the resultant of the line voltage and the induced secondary pressure gradually increases until, when the primary winding is at a position of 90 deg. electrically to the secondary, the resultant becomes equal to the line voltage. This is due to the fact that the primary has no effect on the secondary at this point. As the movable element, however, is rotated beyond the 90-deg. position, the resultant of the line voltage and induced pressure becomes gradually greater than the line voltage until, at the 180-deg. point where the primary pole is directly opposite a dissimilar pole of the secondary, the condition of maximum boost is reached. This occurs because the resultant of the line and induced secondary voltages now become the sum of the two.

The diagram of connections for a polyphase regulator when connected to a rotary converter on a three-phase system is shown in Fig. 4. The connections shown are made according to the delta method. It will be found, upon tracing out the diagram, that each phase of the primary is shunted across one of the three line phases while the corresponding phase of the secondary is in series with one of the legs of the same line phase.

The diagram of connections for the series or secondary winding of a six-phase regulator is shown in Fig. 5. The secondary winding is placed upon the stationary core or stator. The shunt winding carried on the movable core is not shown in the figure. This type of regulator is used in connection with six-phase rotary converters employed on lighting systems. The six-phase converter has a greater capacity than a machine of the same dimensions wound for only three phases. The three-phase transmission, however, is more economical than the six-phase. In practice, therefore, the current is brought to the converter station over a three-phase line and is there changed to a six-phase system by one polyphase transformer or by three transformers, each of which has two secondary windings.

When three transformers are used, the regulator is placed between the transformers and the rotary as shown. The main leads from the transformers pass through the respective regulator secondary windings to the slip-rings of the converter.

Control

The control of regulators is effected by hand or by motor. The latter method, however, is generally used, the motor being mounted at the top of the case and connected by a worm gear directly to the shaft which carries the movable element. A handwheel is also generally provided for shifting the movable element in case the motor is out of service. The motor may be controlled automatically either by a relay used in conjunction with a contact-making voltmeter or by a compensator. The automatic method, however, finds its chief application on feeder regulators. On those used with rotary converters, the most satisfactory method has been found to be that in which the motor is controlled from the main switchboard. This enables the operator to vary the voltage of the converter at will and thus to more easily adjust the voltage of the converter to parallel operation with other machines connected to the same busbars.

The range of voltage variation on induction regulators is generally about 10 per cent. for boosting and 10 per cent. for lowering, making a total of 20 per cent. To secure positive adjustment, the motor should respond quickly to the control of the operator. It should develop maximum torque in minimum time and should stop quickly as soon as the control current is shut off. To accomplish a quick stop a magnetic brake should be used on the motor.

Cooling

Inasmuch as the regulator coils are inclosed, some means of cooling must be provided, as in the case of a transformer, to prevent excessive heating. This is accomplished in one of three ways, namely: by oil immersion, by water pipes in conjunction with oil immersion and by air blast. In the smaller sizes the coils are generally cooled by oil immersion. The oil is contained in a steel tank whose sides are corrugated to present as great a cooling surface to the oil as is consistent with practical construction. In the larger sizes, either the water coils or an air blast is used. With the latter method no oil is necessary. Air cooling is generally used with regulators connected to rotary converters. In this case, the regulator is mounted beside the transformers and receives air under pressure from the same air duct that supplies the transformers.

Efficiency

The efficiency of regulators is fairly high, owing to the small loss of power in the regulator itself. The full load efficiency will generally reach about 95.5 per cent. For a quarter load it will be about 91.5 per cent. The power factor for the various loads varies but slightly and will generally assume a value of about 91 per cent. under ordinary conditions.

A Visible Scale for Torsion Power Meters as used on propeller shafts of steamships is described by Dr. K. Suyehiro, of the Tokyo Imperial University in a recent paper before the Japanese Society of Naval Architects, abstracted in "Engineering." In such a torsion meter, the turning moment is measured by measuring the twist of a certain length of the shaft. A sleeve attached to the shaft at the one measuring point bears a radial arm or a disk, at whose outer edge is a circumferential scale facing inward, a mark opposite the zero point. Halfway between this scale and the center of the shaft is attached a mirror, facing outward, so as to reflect an image of the scale in a nearly radial direction outward. Just beside it is another mirror, attached to the sleeve projecting from the other measuring point of the shaft. These two mirrors reflect images of the scale and of the zero-point mark outward; the geometrical relations of scale and mirrors are such that the images of the scale seen in a viewing telescope appear to be stationary at the center of the shaft. While the image is visible for only a short part of the revolution of the shaft, there will be a sufficiently rapid succession of images to enable the scale to be read.

Argentine Electric Plants—The Santa Fé Electric Tramway Co. is said to be interested in extending its lines 12 miles to the city of Esperanza. A concession will be applied for.

The tramway company in Cordoba which runs a line to San Vicente has applied for permission to extend its present horse lines, and agrees to electrify part of its system.

The government of the Province of San Luis has forwarded a project to the legislature for working an electric tramway, and electric-light and power in the town of Villa Mercedes. It is expected that the project will be approved at an early date.

GAS POWER DEPARTMENT

Utilizing Waste Heat of a Small Gas Engine

n most small gas-engine installations no attempt is le to recover the heat carried off by the exhaust and ket water. As this available heat amounts to about 68 cent. of the total heat supplied to the engine, using heat wherever possible will effect a great saving. The factory of the Sanitary Water Still Co., Jamaica, ., furnishes a good illustration of this statement. Both aust and jacket water are used for heating with a re- ant saving of about $300 a year. The illustrations resent the old and usual layout and the change that cted the saving. This plant has been in operation for ut six months and gives entire satisfaction. The en- e is a horizontal 6½x12-in., running at 300 r.p.m., op- tes on illuminating gas and is rated at 8 hp. It is ed to the shop shafting and has averaged 48 hr. per k for the past three years.

Fig. 1 shows the original installation. The gas was fed the engine through the usual gas bag, and the muffler of the baffle-plate type, fastened to the end of the aust pipe. A 24x8-in. cooling tank, holding about gal. was set at the engine level and piped on the rmo-siphon principle. Due to the low head, however, circulation was very sluggish.

The first step to improve the old installation was to pense with the gas bag with its leaks and yearly re- val. An old hot-water tank about ten times the work-

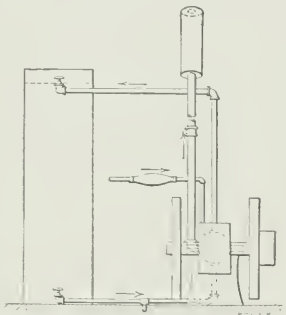


FIG. 1. FORMER ARRANGEMENT

volume of the engine cylinder, was put in the gas e, as shown in Fig. 2. The gas is discharged near the tom and the engine draws its supply from the top. th this arrangement no pulsation of the gas supply is iceable and leaks and consequent expenses are elimi- ed.

The engine exhaust is piped to the drying closet on the ond floor, which contains two racks, each made up of 1-in. pipes 42 in. long. The exhaust passes simul- eously through both racks on its way to the muffler. e temperature of the lower rack averages 140 deg. F., and the upper 120 deg. which keeps the temperature of the drying closet at about 100 deg.

A 20-gal. hot-water tank serves as the muffler. The open drain, which takes care of the condensation in the exhaust gas, is placed high enough to maintain about 1½ in. of water in the muffler. This assists in muffling

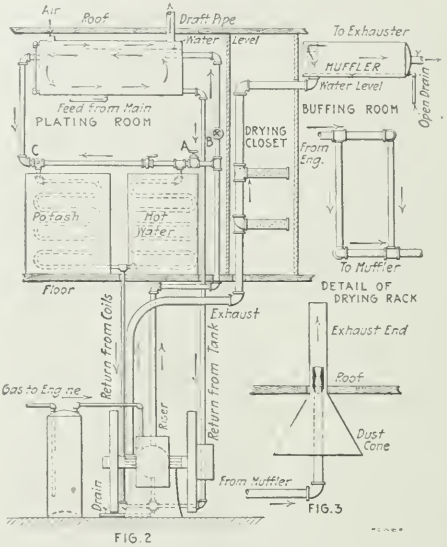


FIG. 2. ENGINE AND TANKS FOR UTILIZING EXHAUST HEAT

the noise of the exhaust. The discharge pipe from the drying racks is carried up in the muffler, to prevent the water from flowing back to the engine. The pipe is capped and partly cut away, as shown, which directs the exhaust against the side of the muffler and breaks up the issuing gas, the temperature of which drops to about 70 deg.

As all the useful heat of the exhaust is given off in the drying closet, there remains only the velocity of the escaping gas that can be converted into work. This is done by means of the exhauster shown in detail in Fig. 3. This acts as an ejector and being placed directly over the buffing lathes, draws out all dust and dirt that escapes the exhaust blower. The exhauster consists of a piece of 2½-in. pipe passing through the roof, which carries a cone made of sheet iron at the end inside of the building. The exhaust discharges into this pipe through the ejector nozzle at the end of the exhaust pipe, carrying along the dust drawn in through the annular opening between the nozzle and the pipe. To get a steady flow of gas the pipe from the muffler is reduced from 2 to 1¼ in., as only practically cold gas passes through this pipe. The reduction does not help much, however: the discharge being intermittent.

The jacket water is used to heat potash in a 24x18x30-in. tank and water in a 18x18x30-in. tank. These tanks are not always in use and provision had to be made to take care of the cooling water in some other way. Space being limited, a 19x50-in. tank was hung to the rafters and piped as shown. With three-way cock C and valve A closed and valve B open, the heated water from the engine rises and is discharged into the top of the tank. There it circulates and is cooled by a counter-current of air passing over the surface of the water. This current is induced by a 2-in. draft pipe, extending 6 ft. over the roof, the pipe acting as a chimney. The air is drawn rapidly through the 2-in. hole on top of the opposite end of the tank, removes the vapor as it rises and carries it along through the draft pipe to the atmosphere. The cooled water returns to the bottom of the cylinder, performs its work and rises to the tank again. The circulation is rapid, as shown by the temperature of the water, leaving the cylinder at 180 deg. and returning at 160 deg. A gage-glass on the tank indicates the water level at all times.

That this method of cooling is very effective is proved by the difference in tank capacity for the same work. This tank holding about 50 gal. does the same work as the old tank of 160 gal. capacity. The manufacturer's specification calls for a 300-gal. tank for this engine.

To heat the water and potash, valve B is closed and A opened; cock C is opened to the coil. Provision has been made to take care of the expansion by connecting the coil return to the return from the upper tank which serves thus as an expansion tank also. The potash is heated to about 100 deg. and the water to 120 deg., while the jacket water averages 140 deg. and the return 120 deg. F.

All combinations needed can be had by manipulating valves A and B and cock C. A faucet for drawing hot water is in the line over the water tank. The pipe on the left of the cooling tank to the coil is used to relieve the coils of air when filling the system, as the filling is done through the tank return; also to heat the potash with water from the cooling tank.

The conditions for a successful installation were rather favorable in this shop, but the novel features introduced and the manner of operating changed to suit local conditions, could be used with profit by many small plant owners. Before the change was made, steam heating was used at a yearly cost of $300. Now, the heat formerly lost gives the same results. The engine, besides driving the machinery, provides the shop with hot potash, hot water, heat for drying and a good exhauster, with the same gas consumption. The cost of the change was $87.40.

Carburetor Troubles and Symptoms

By A. L. Brennan, Jr.

A carburetor is a device for mixing the fuel and air in such proportions that the resulting gas will ignite and form a readily combustible mixture. A good mixture consists of approximately one part of gasoline to 16 parts of air. Of course, this varies to a certain extent with different grades of gasoline and different conditions.

There is no way under ordinary conditions to measure the gasoline or air supply, but with practice the operator should have little difficulty in obtaining a good mixture as the symptoms which point to a lean or over-rich mixture are very marked. Unless the symptoms of faulty carburetion are evident, it is well to look over the ignition and mechanical points before changing the proportion of the mixture, particularly in cases where the motor has been operating regularly.

An overlean mixture will often cause backfiring in the intake pipe or carburetor, although this trouble sometimes results from a leaky intake pipe or float valve, clogging of the float valve or spray nozzle, a defective float or loosened adjustment of the needle or air valve. Much irregular firing can be prevented by periodically cleaning the drip on the carburetor.

An over-rich mixture is usually indicated by dense black smoke and sluggish operation. Also, after-firing in the muffler is sometimes due to an over-rich mixture. Troubles of this nature can be traced to a clogged air intake, too much gasoline through the needle valve or an auxiliary air valve that is stuck. When adjusting a carburetor it is well to have the relief cocks in the cylinders open and observe the exhaust flame while regulating the needle and air valves. A good mixture is indicated by a dark-blue flame verging on violet, which should be accompanied by sharp explosions.

In cold weather it is frequently necessary to obtain an excess of gasoline in the carburetor to facilitate starting. This is done by holding down the "tickler" and thus depressing the float, which allows an excess of gasoline to enter the float chamber and consequently a rich mixture will be formed. In very cold weather it may be necessary to prime the cylinders.

A good mixture is always indicated by a wide range of ignition speeds, that is, with a perfectly regulated carburetor, any advance in the spark will produce a noticeable acceleration in the speed, while if the mixture is poor the spark will have to be advanced considerably in order to accelerate the motor.

The exhaust from a gas engine should be invisible and therefore if the exhaust is smoking, steps should be taken to bring about a remedy. As already stated, black smoke indicates an over-rich or defective mixture, while white or gray smoke indicates an excess of oil. Hence, before attempting to overcome this trouble make sure where the fault lies and act accordingly.

The auxiliary air-inlet valve is usually a ground valve which opens inward, being held in place by a spring of suitable tension. The strength of this spring is carefully determined and is generally set by the manufacturer so that with the proper suction of the motor, as in the event of speeding up, the valve will open enough to allow the required quantity of air to enter the carburetor.

Some gas-engine manufacturers are equipping their motors with kerosene carburetors. Kerosene and heavy-oil carburetors differ from the ordinary variety in that provision is usually made for heating the fuel by some artificial means so that the oil will be raised to a temperature sufficient to insure an efficient mixture. In some cases this change reduces the heat value of the mixture, because the specific gravity of the charge is reduced, and a given volume contains a lesser number of thermal units than when it is at the temperature of the atmosphere. However, good results are being had with kerosene carburetors on gasoline engines, although some trouble is generally experienced when starting. In fact, with few exceptions, engines thus equipped are first started on gasoline, kerosene being fed to the carburetor after the motor has become heated.

HEATING AND VENTILATION

Friction and Inertia of the Heating Art

By James G. Dudley*

The high standards of efficiency being attained today nearly all fields of human effort, to say nothing of the hnical fields of power generation, power distribution, ctricity and refrigeration, warrant inquiry as to the ise of the apparent indifference to progress shown by field of heating and ventilation.

As proof, first of all, that such a negligent attitude sts, it is only necessary to analyze the barrenness of hnical advance (in, say, the last 25 years) made in paratus and the installation of heating and ventilating ipment. Such an investigation must show—in comrison at least with the other branches of engineering—ıt the gains in efficiency and economy have been of ling consequence.

Specifications for heating equipments, disregarding nor specialties and the excluded apparatus required for wer generation, conversion and transmission, may fairbe reduced to the basic terms of heat generator, heat nveyor, heat dissipator, air exhaust and methods of tallation. If ventilation be included there will be in lition air induction, air treatment and air removal.

In justice to the subject, it must be admitted that in s latter department of ventilation an important step advance has been made within the last two decades, hough even its wide adoption is still quite remote, mely, that of air treatment by humidifying, dehumiding, cleaning and cooling with water. Aside from this gle exception, what have been the gains in efficiency l economy in the warming of buildings during the last years? For answer examine the market and the rec-ls: (1) of the generators of heat, (2) of the conveyors heat, (3) of the dissipators of heat, (4) of air exust and (5) of the methods of installation involved in warming of the multiform sizes and types of buildgs, whether by steam under low pressure, vacuum or por or by water circulated by pump or by gravity.

Generators of Heat

In those designed for power generation with heat de-er'd at reduced pressure or as a byproduct, it is safe to that the gains in efficiency and economy whether ght in the mechanical structures or in the processes combustion within them are negligible or at the best uld not exceed a minute percentage. In that class ilt exclusively for low-pressure heating careful investiion will verify the astonishing fact that excepting one r at the most two or three) all are actually less effint than their lineal ancestors of 25 years ago.

The notable exception referred to originated fully 20 rs ago, and its sole warrant to be considered an excepn in this investigation lies in its increase in economy owing to a design of grate which permits of the burning of sizes of coal smaller (hence cheaper) than domestic sizes.

Conveyors of Heat

Neither in efficiency nor in economy have there been gains in the means employed for conveying heat from the generators to the dissipators other than a small reduction in pipe sizes selected by the majority of designers of heating systems. Even from a commercial standpoint there has been back-sliding in quality of product over that obtainable more than 25 years ago, purchase price always excepted.

Heat Dissipators

This term has been employed in preference to the conventional one of "radiator" for reasons of technical accuracy. Here we find but a single step in advance, whether measured in efficiency or physical advantages, the latter applying more directly to recent designs. This is the substitution of sheet metal for cast-iron construction, dating back at least a decade ago. The advantages are a saving of from one-half to three-fifths of the space occupied, of two-thirds of the weight and of one-fourth of the cubic contents. Necessarily this last item makes for quicker action as a heat dissipator in warming up and cooling down, although it is unquestionable that the net output of thermal units must be equal for dissipators of equal rated capacity under constant conditions of heat supply.

The importance of the above advance is minimized when it is learned from trade records for 1912 that the total output of the sheet-metal dissipator for that year does not equal one-half of 1 per cent. of the annual output of the conventional cast-iron type.

Air Exhausting

One of the most serious of the elements opposing high efficiency in heating systems is the contained air which must be exhausted from the system. What have been the gains here over those which were in use 20 odd years ago? The acid test of cold mathematics would play sorry havoc, it is feared, with most of the efficiency and economy gains claimed by the multitude of advocates of vacuum steam-heating systems now appealing for supremacy, but it would not be difficult to secure from the veterans of two decades ago data of systems then existing, which would quite confound the claims, even with mathematical analysis left out of the question. Of vapor heating little need be said supplementing the above broad contentions nor of low-pressure steam with gravity returns. When we turn to the gravity system of heating with hot water as the conveyor medium, not a single gain in efficiency and economy in the methods and apparatus for exhausting the contained air has "seen the market" superior to those which were known and in use by the old timers.

*Consulting engineer, New York City.

Method of Installation

Under this head may be gathered all the accepted means employed by the designers of heating systems to accomplish the results desired. As the heating art has evolved, the best practice has been handed on and down from one to another—much as is the token by the runners in a relay race—without challenge of the basic facts and formulas until today accumulated experience apparently governs where mathematical certainty should blaze the way.

What gains in efficiency and economy have been won in the last two and one-half decades by "skill and experience" in the warming of buildings? Low-pressure steam, vacuum and vapor heating have been weighed in the balance and, it must be confessed, have been found wanting on the points in question. So called gravity circulated hot-water heating has scored apparent gains in the last decade by the reduction of pipe areas, but as a matter of fact piping equally small was employed in installations equally large (if not as numerous) more than 20 years ago.

Pump-circulated hot-water systems operated in connection with power plants have been installed for more than 20 odd years but in limited numbers. Inherent lack of efficiency or economy has proved one limiting cause of this result when the heat generator was a hot-water boiler or a high-pressure steam heater. Another limiting cause of this lack of adoption has been an all too exclusive policy of exploitation in the case of the highly efficient and economical patented system which employs exhaust steam for the main source of heat supply.

From the foregoing analysis it is evident that little, if any, real gains in efficiency and economy in the apparatus and methods of warming of buildings have been made in the last quarter of a century. This has been due to a great extent to the friction of vested interests and the inertia of custom and prejudice.

"Vacuo" Hot-Water Heating

Is it for this reason that "vacuo" hot-water heating, which marks an epoch in the warming of buildings from plants generating their own power, has not received the attention that it deserves? The lack of response to the mathematical analysis of this system might reasonably be excused in other days, but at the present it would almost give warrant to a charge that there exists a "conspiracy of silence" to suppress its good points. However, let it be charged rather to friction and inertia.

For those who have not read the numerous articles in Power on this subject the following résumé is submitted: "Vacuo" hot-water heating comprehends that branch of pump-circulated hot-water heating in which the heat generator comprises primarily a special type of water heater whose source of heat is the steam wasted from prime movers, engine or turbine, preferably the latter, operated condensing as the result of the cooling action of the heat dissipators employed for warming the building, supplemented by a cooling tower and condensing apparatus of sufficient capacity for the surplus of power over heating during winter and for all the power in the nonheating season.

The essence of this system is the production of a high vacuum by the cooling action of the heating system. In practice a well designed installation should average approximately 20 in. of vacuum during the heating season, and thereby secure the additional economy to be obtained by running condensing instead of noncondensing, the latter being the universal method which obtains in such plants not equipped with the "vacuo" system. The vacuum thus produced is under simple manual or automatic control whereby it may be varied at will throughout the entire scale to vary correspondingly the heat content delivered to the water circulated throughout the heating system. There is thus secured a sensitive means of temperature regulation without the employment of thermostatic control and pneumatic valves and piping, as is the case with steam heating.

"Vacuo" hot-water heating contrasted with vacuum steam heating permits the treatment of combined heating and power installations as a single problem instead of a dual one, and secures higher efficiency not only in the generation of power but also in the heating system itself. All or a part of the power load, as far as may be practicable, is balanced against the varying size and character of the heating load, the surplus being treated almost as a separate condensing problem.

A "Vacuo" hot-water plant of 100,000 sq.ft. of radiation coupled with a continuous power output averaging in excess of 500 kw. has been operating continuously for several years past with an average vacuum in excess of 20 in. maintained at the turbine units during the heating season solely by the condenser action of the heat dissipators employed for warming the group of buildings served. Necessarily the efficiency has been high and the economy, when the power has been in excess of the heating, has exceeded by fully 25 per cent. not only the best that has been, but the best that can be achieved by any vacuum steam-heating system with power generators run noncondensing.

All this evidence and much more of like character supplementing it has repeatedly been presented within the past year or two to the designers of other such plants not only indirectly through the technical press, but directly and with especial reference to concrete installations in the preliminary stages of their planning. The system has been denied serious consideration up to date, apparently upon the grounds made famous by the son of Erin, who remarked—after contending in vain against the truth of the descriptions and reproductions of the stately giraffe—that "there was no such animal."

Even if no operating plant had been installed showing by its detailed and accurate records the high efficiency and economy of "Vacuo" hot-water heating, the thermal and thermodynamic exposition of its soundness should have won recognition long before this. The underlying theory cannot be denied. The established facts cannot be controverted. The practical experience out of which the system has been evolved is unique and on a parity with that acquired by any designer of heating systems in this country or abroad. The indorsements won from candid and competent technical authorities after exhaustive investigation are of the highest character.

If the technical world concerned with the design of efficient and economical plants for the warming of buildings served from isolated or central power stations is to avoid the charge of "intellectual ossification," or "a conspiracy of silence," the time is opportune to avoid either horn of this dilemma by indorsement or denial.

ng Costs Favor Hot-Water Systems

By W. L. Durand

he United States a forced hot-water installation to be the exception rather than the rule. This is ably due to the fact that the advantages of hot over steam are not generally known and recognized. at, in most cases, a comparison of the costs of the pes is not made, and where low first cost is desired ssumed that steam is much cheaper and it is in- without any investigation of a hot-water system. llowing comparison of pipe-size schedules may be rest in showing that the piping for a forced hot- or a one-pipe steam installation would not be far nt, while for a two-pipe steam the difference in ould be in favor of the hot water.

following table gives the radiation for each size of rom 1 to 10 in. for steam mains with a drop of re of 1 oz. per 100 ft., for returns and for forced ter based on 170 B.t.u. per sq.ft. per hr. and 20 op with a friction head of 2 lb. per 100 ft. This nts the friction head for an average job:

CAPACITY OF PIPES IN RADIATING SURFACE

Pipe, In.	Sq. Ft. of Rad. Supplied Steam	Return	Hot Water
1	40	400	270
1¼	75	750	570
1½	150	1,500	830
2	300	3,000	1,720
2½	500	5,000	2,630
3	900	9,000	4,650
3½	1,500	15,000	6,800
4	2,000	20,000	9,500
4½	2,800	28,000	12,600
5	3,600	36,000	17,000
6	6,000	60,000	27,800
8	13,000	130,000	57,000
10	25,000	250,000	100,000

me a system containing 25,000 sq.ft. of radia- This would require a 10-in. steam main and a 4½- urn or two 6-in. hot-water pipes. The cost per or the pipe would be about $1.75 for steam and for hot water, or a saving of about 30 per cent. in f hot water.

⁂

sulation of Underground Steam Mains*

show the value, in dollars and cents, of efficiency derground insulation, a section of underground main insulated with standard materials that will loss of 0.034 lb. of steam per sq.ft. of surface per ill be compared with a line insulated with a con- on that will show a loss of 0.14 lb. per sq.ft. per Both these constructions are found in everyday e.

this purpose take an 8-in. steam line 1000 ft. long. n. pipe has 2.25 sq.ft. of surface per lineal foot. radiation loss of 0.034 lb. there will be in 1000 ft. n a line loss amounting to 76.5 lb. of steam per In the second case, with a radiation loss of 0.14 line loss will amount to 315 lb. of steam per hour. e that to generate and distribute this steam will c. per 1000 lb. This will give in a season's opera- eason assumed from Oct. 1 to June 1, 5832 hr.) a ss in the first case equal to $133.84 per year, and second case equal to $551.12 per year.

m a paper read by H. C. Kimbrough before the Kan- s, Water, Electric Light and Street Railway Associa-

The money saved, therefore, on the line loss will be the difference between $551.12 and $133.84, which is $417.28 per year. This money is 6 per cent. on $6954.66, which is the amount of additional money that can be spent to properly insulate the underground construction. On the 2250 sq.ft. of surface in the 1000 ft. of 8-in. main it will be seen that for every 0.01 lb. of steam saved per square foot per hour, approximately $700 can be spent or 31c. additional cost per sq.ft. of underground mains. This amounts to 70c. per lineal foot of 8-in. main.

⁂

Cost of Heating and Power-Plant Apparatus

I have examined with much interest the cost figures given by Mr. Downing in the Nov. 18 issue. Figures of this sort are of great help in getting up approximate estimates of work, although they must be used with discretion, since for the same apparatus prices vary over a wide unit range depending on the size. Also, any item affected by the cost of labor, will be subject to variations depending on the locality.

Temporary setting of direct radiators, $2.25. This item depends entirely on local conditions and the use of any definite price would be misleading unless it were known to apply to the particular locality. For instance, in New York City the standard prices for connecting temporary radiators is $4.50 for a single-pipe job and $5 for a two-pipe job.

The allowance of $50 per thermostat is misleading, as there is no direct relation between the number of valves and the number of thermostats. The use of the following figures would give much closer results. They include all piping, etc.:

Thermostats	$25
Valves	10
Mixing dampers and diaphragm motor	30
Air compressor	125

Cast-iron sectional boilers cost from $28 per sq.ft. of grate surface for a boiler which will serve 300 sq.ft. of radiation to $24 for a boiler rated at 9000 sq.ft.

Shaking or dumping grates cost from $4 to $4.50 per sq.ft. instead of $5 to $6.

A vacuum system complete, including pumps and accessories, will cost from $7 to $10 per radiator installed complete, but the valves themselves may be purchased for $4.50 to $5.

The following are the average costs for steel-plate fans, motors and engines for fans from 4 to 8 ft. in diameter and delivering air up to ¾ oz. pressure:

Fan per 1000 cu.ft. per min.	$12 50
A. C. motor, per hp.	18 50
D. C. motor, per hp.	23 00
Inclosed high-pressure engine, per hp.	17.50
Inclosed low-pressure engine, per hp.	33 00
Open high-pressure engine, per hp.	14 00
Open low-pressure engine, per hp.	27.00

The cost of air washers at $18 to $26 per 1000 cu.ft. of air per min. at 500 ft. velocity is incorrect. They cost from $50 to $60 per 1000 cu.ft. installed. Two recent installations cost $1200 for 22,000 cu.ft. per min. and $2800 for 50,000 cu.ft. per min.

Concrete foundations for engines will cost $9 to $10 per cu.yd., including sand cushion.

Sprinkler systems complete, including tanks, pipe, heads, pump and erection, cost about $7 to $8 per head.

W. L. Durand.

New York City.

EDITORIALS

The Fireman's Task

The fireman's task is twofold: to secure capacity and economy. First and most important, the steam pressure must be kept up. A good fireman keeps the steam pressure within the limits (generally very narrow) of allowable pressure variation. Could he, without a steam gage, tell whether or not he was holding the pressure? Is there an engineer or superintendent of a boiler plant who would expect him to do it?

The second important part of the fireman's task is to generate the greatest possible amount of steam per pound of coal fired. Does he succeed in doing this? Not at all. Do you expect him to do it? Yes. But what help or guide do you give him? You set a standard of steam pressure to be maintained and give him a steam gage to guide him, and he makes good on this portion of his task. Unfortunately, he does it by sending 30 or 40 per cent. of heat up the chimney, whereas this waste should not exceed 20 or 25 per cent. So long as he has nothing to guide him, no means of knowing whether he is wasting much or little, or when he is working wastefully or economically, so long as he is working blindly, he cannot be expected to make good on the second part of his task and he doesn't.

Set the standard and give the fireman the means of knowing what he is doing and he will make good in the direction of economy as well as capacity.

The percentage of CO_2 is an index of efficient combustion and, in combination with the temperature of the escaping gases, is a measure of the heat wasted up the chimney. Therefore, as one means to the desired end the fireman could be provided with a gage showing the percentage of CO_2 as prominently as the steam gage shows the pressure and the water glass shows the water level.

The fireman sees the hand of the steam gage dropping below the required pressure and he immediately attends to his fires. He shovels more coal, and opens the damper (if that is within his control, but only too frequently it is not), he shakes the grate, slices the fire, he does one, several or all of these things, as his experience and judgment dictate as necessary or expedient, and keeps at it until the hand on the steam gage moves the other way. Whether he is firing economically or wastefully he does not know. He has no means of telling whether he is burning the coal with 30 or 40 per cent. excess air, which is entirely sufficient, or whether he is chasing 100, 200 or 300 per cent. too much air up the chimney. He cannot tell and the chief can only suspect it from the coal bills.

If the steam rises above the specified pressure he stops shoveling coal. He may close the damper or not as suits his convenience. Allowing the fire to burn thin permits a large volume of air to pass through the fuel. This air carries away the heat—wastes it—and the generation of steam is checked. The latter is what he was after. He must not let the steam pressure exceed the limit set. He may even find it expedient to open the fire-doors occasionally. Again, he wastes the heat by sending a large volume of highly heated excess air up the chimney.

He knows he must keep the steam pressure within prescribed limits or lose his job. The steam gage enables him to do this and he does it. The fireman knows that you know and that is the principal reason why he makes good.

There are some firemen of an observing mind who use their brain to save their muscle. They have found by experience that by keeping an even fire bed, by preventing holes from burning through, by adjusting the fire thickness to the available draft, or adjusting the draft to the thickness of fire necessary to keep up the steam pressure, by stopping up leaks in the setting, etc., they can reduce the labor of shoveling coal and hence keep up the required steam pressure with less exertion. The great majority, however, do it by main force and stupidity. All they know is that if the steam pressure drops they must shovel more coal, and if it goes above the required mark they must shovel less. Such firemen waste several times their wages in coal every day; but you have no means of telling which of your firemen are firing more and which less efficiently. Only too often the man who shovels the most coal is considered the best fireman, when the reverse is more likely to be the case.

Under these circumstances it is much more surprising that occasionally a boiler plant reaches an efficiency of 75 per cent. than that the average does not exceed 65 per cent. There is no good reason why under fairly favorable conditions an average efficiency of at least 75 per cent. should not be maintained.

To attain and maintain maximum efficiency you must provide the fireman with a means of knowing what he is doing, you must set a standard to be worked to and you must provide yourself with the means of knowing how well the fireman succeeds. The fireman must be aware that you know when and how much he falls short. Thus provided with the necessary guide and moral incentive the fireman will make good in the second part of his task as well as in the first.

❖

The Shirk

In many small steam plants, running day and night, is found the shirking engineer. He is the type of man who goes off watch leaving a dirty engine, empty oil and grease cups and half-filled lubricators or oil tank. The drip pails and pans are filled to overflowing, and often much needed adjustments or repairs are neglected, and his relief must do the shirk's work to keep the plant going. In the boiler room there are thick, unclean fires, low water and filled ashpits. The gage-cocks leak and the water glass is covered with lime, or the lamp back of the glass has burned out or been broken. Perhaps the pumps should have been packed but are left to leak and blow.

lories in the fact that he can do these things. to them not only because he is a shirk, but chief engineer is watchful, neat and painsand his proper pride compels him to do double this respect.

course, the shirk, after the manner of his kind, de- in "putting it over," and for a time he thinks he is clever individual. But after a while he is informed new engineer will stand watch in the place of the e; the latter has secured a better position. Eventual- shirk, if the new man will not be imposed upon, es sour and disgruntled, and in most cases soon his level in a little plant where he is still the "engi- but between times wheels his own coal and cleans rn fires.

e remedy for this condition is mainly in the hands t engineer who has the firmness to refuse to accept mposition from the shirk. He makes it plainly un- od at the outset that, while he wants to do every- possible to prevent friction, to establish pleasant ons with his fellows and to help gain the commen- of the owners by good service—in the same plant him there is no room for the shirk!

ese are some of the reasons why no engineer should xception to the man coming on watch, satisfying lf that everything is in proper operating condition he assumes charge. It should be plain that his ation is an added safeguard for both of them, and t sensibly be taken as reflecting upon the skill or of the engineer about to be relieved. The careful counts his change, the careful seller expects it; it heck upon the element of error that may enter into transaction. A straight cashier never resents hav- is accounts audited.

⁂

Welded Joints

metal could be joined by welding so that the joint nown to be as strong as the metal itself, the riveted with its lack of symmetry and loss of strength could ne away with, and pressure vessels be made neater, r and safer than by the process of metallic stitching n general use.

ny welded joints have been tested in which the piece in the solid metal outside of the weld, and many s in which the failure of the weld showed a tensile gth nearly equal to that of the metal of the sheet. his is not *a priori* proof even that the welded joint e made safe. In the autogenous process of welding is a line or a film of molten metal interposed be- the welded surfaces. This metal comes from the ar or welding wire which the workman fuses with orch and runs between the heated surfaces of the to be joined. What is the character of this metal it has been melted, run and allowed to set without ing? What is the effect of the heating process upon dges of the sheet itself? What internal stresses are p by the intense local heating and cooling? Is the given a high tensile strength by one or more of causes to the detriment of some other quality?

ese observations are not intended to throw distrust the welded joint as used for a rapidly increasing ber of purposes, but are prompted by the extreme on which should control the extension of that use to vessels of considerable size under pressure and containing large amounts of stored energy. That ninety-nine per cent. of the joints so made were as strong and reliable as though the metal were continuous would not qualify the process if it were impossible to say which one of every hundred boilers might have the defective weld. A riveted joint is at least safe to start with. What is needed is a means of telling whether a welded joint is all right by some process other than the destruction of the joint.

In Germany a search is being made for such a process. In response to an offer of a prize for the best method, twenty-six contestants sent in suggestions. None of these in the opinion of the board of expert judges offered a complete solution of the problem but five of them offered possibilities and will be tried out. (See page 944.)

Some of those who are doing autogenous welding successfully and who know that it can be done so as to be perfectly safe and satisfactory even in the longitudinal joint of a large boiler shell are impatient of this research, and doubtful of the finding of a method which shall be at the same time reliable and simple enough for commercial use. Henry Cave, in a paper abstracted on page 940, contends for a "three-license system" under which the apparatus, the operator and the party undertaking the work shall all be examined and licensed. It is apparent why the apparatus and operator should be approved, but the operator while he may be skilled in the use of the torch is usually not a judge of the best materials to be used on a particular job, whether or not heat treatment is necessary, whether in a complicated structure the piece is in compression or tension, etc.

Autogenous welding is being successfully used on many comparatively large fittings under pressure. Lengths of steam main and even receivers for engines of considerable size are made with the fittings welded in and the receivers, we believe, with welded seams. We should be quite willing to accept as safe a joint which Mr. Kautny or Mr. Cave had made or seen made. Perhaps it may do to depend upon men who have the certified approval of these or other competent authorities. But we shall all feel better about it if they find that simple, practical, positive method of telling whether the weld is sound.

⁂

Credit to the Central Station

While the efficiency methods as applied to the workrooms of mills and factories influence the economy of the power plant, it must be recognized that the central-station companies more than industrial efficiency engineers, are the ones who have furnished the conditions that stimulate most isolated-plant engineers to greater effort.

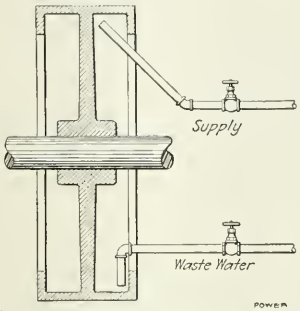
A central station is a competitor of the smaller plants in the same locality. As it sells power for profit its methods of power generation and transmission are usually efficient and thoroughly systematized. They should and must be. The central station as an institution has forced power-plant engineers, as a class of labor, to better efficiency just as any competitor who adopts improved methods forces others in the same business to do likewise.

By the foregoing we do not mean to infer that progressive engineers are rare. Thanks to the inherent thoroughness, some engineers conduct their plants in a manner comparable with the best managed central stations. These men are pioneers, are vanguards to the host of others who must be told to follow.

READERS WITH SOMETHING TO SAY

Cooling Prony-Brake Pulley

In preparing to take the brake horsepower of an automatic engine I noticed that the governor pulley had inward-projecting flanges at the rim. The prony brake was applied to this pulley and the rim kept cool by a small stream of water applied to the inside of the rim, as shown in the illustration, which does not, however, show the governor mechanism. The outlet pipe had to be carefully fitted to avoid striking the blocks and levers of the governor and still be close enough to the rim to suck out the water before it overflowed the flanges.



Cooling Pulley Used as Brake

This arrangement may be used with any pulley which has suitable flanges. If very much water is used or extreme accuracy is desirable the stream of water should be projected in the same direction as the rim is traveling and at the same speed. Otherwise the rim would use some of the power of the engine in bringing the water up to speed.

Fred Boone.

Davidson, Okla.

Heated Air for Steam-Boiler Furnaces

Some years since a series of experiments was conducted to determine the value of a heated-air supply for steam-boiler furnaces. These experiments were financed by an association of mill and factory owners and extended over a long period. They were very thorough as well as expensive and showed that about as much could be gained by heating the air supply to the furnace as is gained by heating the feed water to a boiler by some source of heat that otherwise would be wasted. In extreme cases the saving was as much as 14 per cent.

This being the case it becomes an interesting question as to why this method of economizing is not more generally used than it is at present. Is it because of lack of knowledge of the benefits to be derived, or is it because of the expense of fitting up the proper apparatus, such as was needed in the experiments referred to above, or is it because this question has never been pressed home to the people who pay the fuel bills? Great expense is incurred to save every possible heat unit for the feed water and to this end elaborate economizers are installed between the boilers and the stack, and steam traps are used to return the hot water to the boiler without undue loss of heat. All of this is commendable if done properly, but the heating of the air supply to the furnace seems to be a mine of wealth practically untouched at present and one that seems to be worthy of serious consideration.

Aside from the experiments and tests above referred to and as a side light on what effect the temperature of the air has on the economy of combustion in everyday practice, it may be stated that some years since a series of tests on an internally fired boiler were made by four well known experts. These men were and are all members of the American Society of Mechanical Engineers and the tests were run in accordance with the code of rules approved by this society.

The tests were made at different seasons of the year. Each test was under the direction of a different expert, but all weights, etc., were taken by the same assistants and the boiler was fired by the same skillful fireman. In fact, all the conditions with the single exception of the temperature of the air were as nearly alike as they could be made. The highest duty was obtained in the warmest weather and this in a way confirms the theory that the temperature of the air supply has an appreciable effect on the duty obtained.

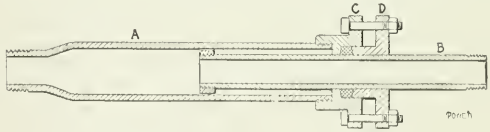
W. H. Odell.

Yonkers, N. Y.

Home-Made Expansion Joint

The accompanying sketch shows a 3-in. expansion joint which is practical in service and economical to manufacture and has an advantage over the type usually made in that it may be made for any length of stroke without great additional expense.

The sleeve *A* is a piece of 4-in. pipe with a standard thread on one end and swaged to 3 in. with standard 3-in. thread on the other end. The plunger *B* is a piece of 3-in. pipe and has a standard thread on each end. One end is for the pipe coupling and on the other end is screwed a short ring to prevent the plunger drawing entirely out of the joint. This plunger is trued up and polished on the outside between the threads. On the 4-in. end of the sleeve *A* is screwed the flange *C*, which is bored out for packing and fits over the plunger *B*. The flange *D* forms the gland for the packing box and is bored to fit freely over the plunger *B*. Both flanges (*C*



Section of Home-Made Expansion Joint

drilled for four 5/8-in. bolts for drawing up ...ng. Plunger B is free to slide back and forth ...istance between the coupling on one end and the ... on the other.

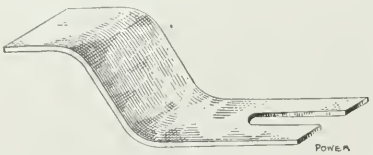
have made several of these expansion joints recently they are giving good satisfaction.

L. E. Stephens.

ellows, Calif.

A Pump-Valve Kink

ith some types of pumps and valve designs it is very ig to screw the spindle fast and at the same time hold spring and cover plate from falling down into the p chamber. To obviate this trouble, I use a strip of



Tool to Hold Pump-Valve Spring

n. sheet brass, about ½ in. wider than the valve stem, slotted as shown.

y compressing the valve spring when it and the cover e and valve are on the spindle, and by getting the le edges of the slotted brass strip in the threads of spindle, the latter may be easily screwed fast.

J. M. Coleman.

anchester, Eng.

Cause of Knock in Pump*

ading the experiences of Mr. Hurst and Mr. Ferguson he cause of knocks in pumps, I wish to relate an exence I recently had with two 8x5x12-in. boiler-feed ps. These pumps are of the duplex type with packed ons. The valves used are standard composition as rally used for hot water on feed-pump service. No. mp had been overhauled and two new piston rods in. When the pump was again put in service it ed good at first, and after a few days it worked well low speed, but on speeding up both pistons would p about an inch at the beginning of each stroke. To ppearances either the steam piston or water piston loose on the rod. As new rods had been put in it thought possible that they might be a little loose.

he water end was opened and the nut on the end of rod tried and found tight. Then the steam cylinder opened and the nut on the steam end found tight. nake sure that the trouble was not in the piston rods was taken out and the water piston fitted on it and ed to be a good fit. The rod was then put back in e, and repacked, and the cover taken off the valve nber where the cause was apparent. Here it was d that three of the suction valves and two of the arge valves were binding on the stem so tightly that would be held open against the action of the spring l the reversal of the direction of the water through the s together with the tension of the springs closed them. t was what caused the quick jerk at the beginning he stroke. These valves were a good fit when put in, and must have expanded on being heated up after a long shutdown. They were bored out about 3/32 in. and put back in place and no further trouble occurred. The only part that is not clear is that inasmuch as these valves were in use several months after they were put in and gave no trouble of this kind, when the pump was started after a shutdown of two months five out of the eight valves were tight. No. 1 pump was overhauled at the same time, and had been in use about six weeks when the same trouble occurred in it as in No. 2. Two suction and two discharge valves were found stuck on the stems, and after being bored out, stopped the knock.

It has been my experience that as a rule the larger part of trouble in pumps can be traced directly to the valves. It may be due to excessive leakage, or a broken valve, broken spring, stud breaking off or working out, valves too tight on the stem, or gasket between the suction and discharge-valve deck blown out, any of these conditions will cause trouble, and may cause a heavy knock which appears to be and actually is in the cylinder, but the cause of it will be found in the valve chamber. If the suction pipe is long, or its opening restricted or the lift is high the pump may knock when running at high speed, but this knock will be of a different nature than that caused by defective valves and would not be mistakened by the engineer.

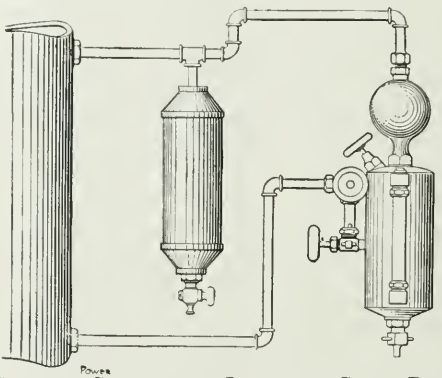
J. C. Hawkins.

Hyattsville, Md.

*"Power," Sept. 16, p. 404, Nov. 18, p. 727.

Sediment Collector for Lubricator

The lubricator is a sensitive and delicate apparatus, and, therefore, any sediment collecting in the oil and water tubes or pipes will undoubtedly cause trouble. Trouble is more likely to occur when the feed water is



Sediment Collector in Lubricator Steam Pipe

treated with chemicals, such as soda ash, on account of the foaming of the boilers.

An inexpensive attachment, which will provide a protection against the collection of sediment in the lubricator, is illustrated. A few extra pipe fittings are needed to make the collector for the steam connection to the lubricator, reducers being used on each end of a pipe forming the body of the collector. By opening the small drain cock at the bottom of the collector, the sediment may be blown out very quickly.

T. J. M. Clute.

Schenectady, N. Y.

The Effect of Air in Feed Water

Mr. Boone's letter, in the issue of Nov. 25, is interesting in that it calls attention to the possibilities which lie in the future development of power apparatus wherein the working fluid is a mixture of a vapor and a gas, for instance, as in this case, steam and air. It is not necessary at this time to enter into any discussion as to whether those possibilities are attractive or otherwise. It is enough to note that in the development of the gas turbine, it has been proposed, among other methods of attacking the problem, to combine the generation of steam with the production of the gas, and to expand them both together.

So far as the discussion referred to is concerned, it looks as if the advocates of the open heater had the best of it, because their argument was certainly based upon undoubted fact, while that of the other side involved some incorrect assumptions.

In the first place, pumping air into the boiler with the water was not accomplished without throwing any more work on the feed pump. The pump simply acted as a combined water pump and air compressor, and the theoretical work chargeable to each function could be ascertained, knowing the relative quantities of water and air. Therefore, the air is not "compressed into the closed heater and boiler without any expenditure for power."

In the second place, while it is true that "it requires no heat to evaporate it as it is already in the form of a gas," it does require heat to bring it to the working temperature, and the fact that its specific heat is less than that of water is not the advantage it appears to be. As a matter of fact, to transform heat into power, the working fluid must be put under pressure and then allowed to expand. With a vapor, the pressure is obtained by boiling the fluid, the process entailing a loss of the heat used in changing from liquid to vapor. With a gas, in order to keep down the size of apparatus, the pressure is obtained mechanically at a considerable loss of energy, by means of a compressor, rather than by the application of direct heat.

Now, the average compressor will put into the gas it compresses, about one-half of the energy consumed by it. The operation of a steam pump as a compressor might show something like this efficiency, if it happened to be the right kind of pump, but it would be safer to assume a greater loss than that stated.

Through the same temperature range, the theoretical work done by the air in expanding will be equal to the work done upon it by the compressor, but, it has taken double its stored power to compress it, therefore, even if its expansion were 100 per cent. efficient, it could only deliver half the power put into it. So far, then, the pump is putting into the system twice as much energy as is realized.

Of course, there is a gain due to the difference in temperature of the air in the heater and the air in the boiler. This would not in practice amount to more than 300 deg. F., and would not represent sufficient gain in volume to make up for the loss in compressing.

The matter of the different specific heats does not enter into the problem, because the same specific heat applies both to the expansion and the compression of the air, and the theoretical power thus put into or taken from a gas, depends upon its particular specific heat.

Putting the air in at low temperature, that is, compressing efficiently, expanding from as high temperature as possible (superheat) and running condensing (sounds impossible, but it is possible with modern types, by simply making provision for handling more than the traditional 10 per cent. of air), will make such a system more nearly possible, but even then it will be found better to keep the air out, until much higher temperatures are possible than we dare use today.

There is one feature that deserves mention: that is, that when any considerable amount of air is mixed with steam, the mixture becomes unsaturated, though it may be at the temperature of saturated steam for that pressure, and, in expanding, condensation will not take place until the mixture has reached its "dew-point." As the temperature of total condensation of such an atmosphere is not reached short of the freezing point, investigation along these lines presents some interesting problems as to what additional power is realized from the combined expansion of a gas and a vapor, as distinguished from the sum of their expansions taken separately.

R. Carpenter.

East Orange, N. J.

Safety-Valve Problem

H. H. Hastings, in the Nov. 18 issue, relates an experience with a safety valve, stating that it worked all right until it lifted about $\frac{3}{16}$ in., when it moved suddenly to a wide-open position.

The action was unquestionably due, first to the fact that the safety-valve area was not adequate and could not, therefore, deliver the excess steam, unless wide open; second, the uniformity of movement was evidently caused by excessive friction in the first part of the valve travel, due to a bent guide pin or scale accumulation.

The area of a safety valve is determined by reference to the mechanics of fluids in motion or upon the results of experiments to ascertain the area necessary for the escape of all the steam the boiler could give. The most usual method is, in the absence of generally recognized rules, to proportion the valve area according to the grate surface, heating surface or horsepower of the boiler. The safety valve is designed on the assumption that the static pressure in the boiler will lift the valve, when this pressure exceeds the exterior pressure or that due to the weight, on the valve. The rise of the valve is sudden whenever there is an excess pressure on the boiler. The height to which a valve will rise cannot be determined theoretically, but the question has been conclusively settled by Burg, of Vienna, after careful and extensive experiments, the results of which are shown in the accompanying table.

POUNDS STEAM PRESSURE								
12	20	35	45	50	60	70	80	90
RISE OF VALVE IN INCHES								
$\frac{3}{64}$	$\frac{4}{64}$	$\frac{6}{64}$	$\frac{8}{64}$	$\frac{8}{64}$	$\frac{8}{64}$	$\frac{12}{64}$	$\frac{12}{64}$	$\frac{12}{64}$

It will be understood that the experiments were conducted with well proportioned safety valves, and under normal conditions.

If a valve be held down until the pressure increases to 2 or 3 lb. more than that for which the valve is weighted then released, as Mr. Hastings has done, it would be impossible to arrive at conclusions, as the valve, having lost its balance, would necessarily fly wide open.

I do not think that there is any ground for apprehen-

y because a valve rises too high, as in any case elieves the boiler of excess pressure, and would ve an increased evaporation greater than a safety or lesser lift. The danger lies in the fact that it not pass all the steam generated. A high lift is due adequate valve area.

t there is a decided and immediate danger in holdhe valve down until the pressure increases above that which it is weighted, as, upon releasing it, the valve its balance and the effect would be similar to openthe main valve suddenly; a great volume of steam is sed, causing water-hammer and, perhaps, an explo-

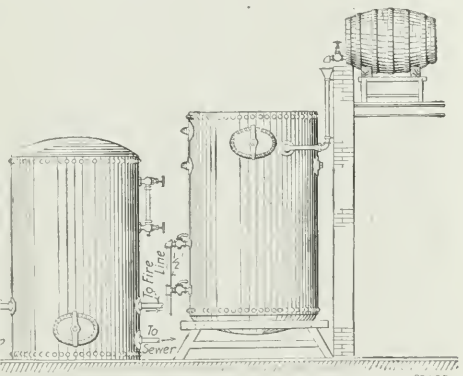
r. Hastings' theory, that the high lift of the valve e to the velocity of the escaping steam impinging the valve disk, thereby increasing the pressure is nable. If it were correct, the valve would be kept by the outrushing steam until the boilers were totally usted. The effect of increased velocity, contrary to Hastings' theory, is manifest in a decreased lift of alve; the greater the pressure, or higher the velocity, less the rise.

VICTOR BONN.

ashington, D. C.

Air Tank Used for Oil Storage

hen the plant in which I am employed was installed ir-pressure tank was put in the fire line to insure ust shock from the intermittent action of the duplex p. This pump was controlled by a governor. One



SPRINKLER-SYSTEM TANK FOR OIL STORAGE

the governor failed to act and the pressure in the increased so that it had to be discontinued for that ice.

he tank laid around, useless, until several barrels of ne oil arrived, when it was used to store the oil, as higher temperature of the store room thinned the and the barrels began to leak. The tank was put in oil room, inverted on a wooden base and painted. The er-glass cocks were removed and stop-cocks put in r place, piped as shown. Plugs were put in the tank cts. The oil is put in by gravity, this being possible ecount of the location of the tank with relation to the ide ground level. A hole is bored in the end of the el and a piece of pipe with a valve is screwed in. This is done before the barrel is put on the horses. Then the valve is opened and the oil soon runs out.

The top cock is used to draw oil as long as it will run from there. When the supply in the tank gets below the top cock it is time to order more.

H. G. GIBSON.

Washington, D. C.

Clear Water from Muddy River*

In the issue of Oct. 28, there is an article with the above heading. I would say that the water in the hole is clear because it is furnished by a spring. The river water does not enter the hole at all, there being a constant upward flow of clear water that keeps out the sedi-

PROBABLE LOCATION OF SOURCE OF WATER

ment. If the cavity could be sealed as shown in the sketch, and the water allowed to escape through the pipe, it would, perhaps, be discharged several feet above the surface of the river.

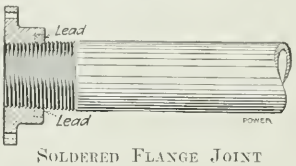
W. B. ODELL.

Birmingham, Ala.

Pipe Joint Soldered at Flanges

We have in our plant a 6-in. steam line supported on saddles at the top of posts about 14 ft. high.

This pipe continues through the yard on these posts for about 300 ft., connecting boilers at either end of the works. We have had, from time to time, leaks in the threads at the ends of lengths where they screw into the



SOLDERED FLANGE JOINT

hub of the flange unions. To take down pipe would be an expensive job, as we would have to cut off pipe and make new threads or substitute new pieces or flanges, as the conditions warranted. To avoid taking down the line we split off flanges with a cape chisel at the bolt holes to inspect the threads. If the thread is poor well within the thread length of the flange, we spread the line open enough, and screw on a new flange with a recess at the back of the hub, into which we pour lead and calk the joint to insure a tight job. The cross-section of one of these flanges illustrates the idea. This may, or may not, be a new idea.

F. R. MAW.

Hancock, Mich.

*"Power," Oct. 28, p. 611; Dec. 2, pp. 976, 977.

INQUIRIES OF GENERAL INTEREST

Coal—What is the difference between hard and soft coal, and why does the former produce less smoke than the latter?

M. S. M.

The main difference between hard and soft coal is that soft coal volatilizes easier, which is the reason why hard coal produces less smoke.

Air-Compressor Power—What amount of power will be required to drive a 10x10-in. compressor making 110 r.p.m. and compressing the air to 40-lb. gage pressure?

Assuming the compressor to be a single-stage compressor in ordinary good condition and of about 80 per cent. mechanical efficiency, the net power required to be delivered to the compressor would be 6½ to 7 hp. An 8- to 10-hp. electric motor should be used to drive it.

Belt Sufficiency—Will a two-ply leather belt 16 in. wide transmit 150 hp. between two 40-in. pulleys on 15-ft. centers at 250 r.p.m.?

C. F.

The belt referred to would not be suitable for more than 106 hp. and would not transmit 150 hp. without giving considerable trouble. For transmitting 150 hp. either the speed of the belt or its width should be increased about 50 per cent.

Valve Lap—In the designing of a slide-valve engine is any difference made in the lap on the two ends on account of the angularity of the connecting-rod?

E. P.

An allowance for angularity of the connecting-rod should be made in fixing the lap on a slide valve, making the lap at one end greater than the other, and for important work such allowance is generally made by careful designers and builders of slide-valve engines.

Forced Draft—Is there not a loss in efficiency when boilers are operated with forced draft? The temperature of the flue gases must necessarily be high, unless it is a water-tube boiler especially baffled for this manner of working.

J. B.

Forced draft is only applied when the natural draft is insufficient for the rate of combustion required or in lieu of natural draft. When properly adapted to the requirements of air for proper combustion the temperature of the escaping gases is no higher than from introduction of the same amount of air by natural draft.

Fan Power Consumption—A 6-ft. fan is driven at 600 r.p.m. from a line shaft running at the same speed, by 24-in. pulleys on both shafts. What effect will it have on the power consumption to substitute two 48-in. pulleys?

L. N.

With either set of pulleys, the fan being driven at the same speed, there would be the same delivery of air and consequently the fan would receive the same number of horsepower. A single advantage in driving with the 48-in. pulleys is that the belt would travel twice as fast as with 24-in. pulleys and the driving tension in the belt would be half as much, which would make about half as much pressure on the hanger boxes and would reduce the shafting friction nearly one-half.

Burning Wood—In substituting wood for coal in a boiler furnace, how much more fuel will be required and what changes will be necessary in the furnace?

H. F.

It is enough to allow 2½ lb. of wood as equal to 1 lb. of coal, if the wood does not contain over 20 to 25 per cent. of moisture. Such wood is usually known as "dry," and whatever greater quantity of moisture may be in the wood will have to be evaporated in place of about an equal evaporation of the boiler. For wood burning there should be fully half more area of grate openings and the boiler should be 50 to 75 per cent. higher above the fire, and the flue-chimney capacity should be about twice as much as for coal. With natural draft and dry wood 20 to 25 lb. of wood should be burned per hour per square foot of grate, and with forced draft 40 to 50 lb.

Water-Meter Correction—What corrections must be made to the readings of a hot-water meter, calibrated to read in pounds at 170 deg. F., but used with water at 100 deg. F.?

J. A. P.

The weight of any unit of volume of water, as a cubic foot, at a temperature of 100 deg. F., is 62.02 lb. and at 170 deg. F. the weight is 60.77 lb. Therefore, readings of a water meter which is calibrated for 170 deg. F., are corrected (for equivalent weight of water) when the water is at 100 deg. F., by multiplying by the fraction

$$\frac{62.02}{60.77} \text{ or } 1.0206 \text{ as a correction factor}$$

Smoke Rings—A locomotive or traction engine after standing idle will often emit rings of smoke for a few revolutions when started. What is the cause?

E. P.

Rings of smoke and steam are formed by a full sharp exhaust which occurs more frequently when the link valve gears are full gear forward or backward. The exhaust and smoke are rolled up against the inside of the stack and, especially when discharged from a straight stack with a contracted outlet, are discharged in rings. A paste-board box filled with smoke will vent rings through a clear round hole in the box by sharply tapping the sides of the box, which shows that the ring is formed by sharp puffs being retarded by the edge of the opening.

Compressing Air with Fan—What is the limit to which air can be compressed with a centrifugal fan? Is it possible to store up air in a tank by means of a fan at a pressure of 4 or 5 lb.?

W. A. M.

The commercial limit of pressure by fan blowers of ordinary construction is about 16 oz. or 1 lb. per sq.in. The action of fan blowers is by free inlet and the accumulation of pressure, being by centrifugal effect resulting from high rotative velocity, the present methods of construction will not admit of practical velocities necessary for higher pressure than 16 oz. as above. It is not practicable, therefore, to store up 4 to 5 lb. per sq.in. pressure with a fan blower. However, belt driven, positive pressure blowers or turbo-compressors can be used for the purpose.

Water in Air Line—We have considerable trouble from water in our compressed-air line. What can be done to avoid it?

F. T.

The trouble results from moisture taken in with the air supply to the compressor. The inlet should be removed from a moist atmosphere such as that of a kitchen or laundry. Any compressed-air line should be run without pockets in the line and should be pitched downward away from the compressor with drip cocks at the lowest points for draining the line when necessary. A remedy for removing moisture from atmospheric air taken into the compressor would be to draw the air through box conduits of wood nearly filled with lime, having the boxes made with loose covers removable for drying out the lime at intervals.

Saving by Feed Heating—What horsepower will be saved if 30,000 lb. of water per hour at 259 deg. F. is returned and mixed with the feed water at 218 deg.?

W. D.

The heat units realized would be

$$259 - 218 = 41 \text{ B.t.u. per lb.}$$

and this, multiplied by the number of pounds, would be

$$30{,}000 \times 41 = 1{,}230{,}000 \text{ B.t.u. per hr.}$$

In converting the feed water into steam and by employing an engine to convert this into useful work, a large percentage of the heat units would be lost. The usual boiler horsepower consisting of the evaporation of 34½ lb. of water from and at 212 deg. F., or equivalent, is equal to the development of 33,479 B.t.u. per hour, and therefore the boiler horsepower which would be saved would be

$$\frac{1{,}230{,}000}{33{,}479} = 36.7 \text{ boiler hp.}$$

ENGINEERS' STUDY COURSE

Trigonometry—VI

Last Lesson's Answers

21. As the cotangent of any angle is equal to its cosine vided by its sine

$$cot\ (A + B) = \frac{cos\ (A + B)}{sin\ (A + B)}$$

nerefore, from equations 13 and 11

$$cot\ (A + B) = \frac{cos\ A\ cos\ B - sin\ A\ sin\ B}{sin\ A\ cos\ B + cos\ A\ sin\ B}$$

viding the numerator and denominator of the second rm by $sin\ A\ sin\ B$.

$$cot\ (A + B) = \frac{\frac{cos\ A\ cos\ B}{sin\ A\ sin\ B} - \frac{sin\ A\ sin\ B}{sin\ A\ sin\ B}}{\frac{sin\ A\ cos\ B}{sin\ A\ sin\ B} + \frac{cos\ A\ sin\ B}{sin\ A\ sin\ B}}$$

nceling and substituting the cotangent for the cosine ided by the sine,

$$cot\ (A + B) = \frac{cot\ A\ cot\ B - 1}{cot\ B + cot\ A} \qquad (17)$$

22. As

$$cot\ (A - B) = \frac{cos\ (A - B)}{sin\ (A - B)}$$

om equations 14 an 12

$$cot\ (A - B) = \frac{sin\ A\ sin\ B + cos\ A\ cos\ B}{sin\ A\ cos\ B - cos\ A\ sin\ B}$$

ain dividing the numerator and denominator of the ond term by $sin\ A\ sin\ B$

$$cot\ (A - B) = \frac{\frac{sin\ A\ sin\ B}{sin\ A\ sin\ B} + \frac{cos\ A\ cos\ B}{sin\ A\ sin\ B}}{\frac{sin\ A\ cos\ B}{sin\ A\ sin\ B} - \frac{cos\ A\ sin\ B}{sin\ A\ sin\ B}}$$

nceling and substituting the cotangent for the cosine ided by the sine,

$$cot\ (A - B) = \frac{1 + cot\ A\ cot\ B}{cot\ B - cot\ A} \qquad (18)$$

23. From equation 15 (last lesson)

$$tan\ 75° = \frac{tan\ 30° + tan\ 45°}{1 - tan\ 30°\ tan\ 45°}$$

ven $tan\ 30° = \frac{1}{\sqrt{3}}$ and $cot\ 45° = 1$. The tangent and angent being reciprocals $tan\ 45° = 1$ also. Now substituting

$$tan\ 75° = \frac{\frac{1}{\sqrt{3}} + 1}{1 - \frac{1}{\sqrt{3}} \times 1} = \frac{\frac{1 + \sqrt{3}}{\sqrt{3}}}{\frac{\sqrt{3} - 1}{\sqrt{3}}} = \frac{1 + \sqrt{3}}{\sqrt{3} - 1} = 3.7321$$

ich agrees with the value given in the table in Lesson

24. From equation 18

$$cot\ 15° = \frac{1 + cot\ 45°\ cot\ 30°}{cot\ 30° - cot\ 45°}$$

Given $cot\ 45° = 1$ and $tan\ 30° = \frac{1}{\sqrt{3}}$. Then $cot\ 30° = \sqrt{3}$. Substituting

$$cot\ 15° = \frac{1 + 1 \times \sqrt{3}}{\sqrt{3} - 1} = \frac{1 + \sqrt{3}}{\sqrt{3} - 1} = 3.7321$$

which also agrees with the table and incidentally proves (as it should) that the tangent of an angle is equal to the cotangent of its complement, for $75° + 15° = 90°$.

25. Required an expression for $tan\ (A + B) - tan\ (A - B)$. Combining equations 15 and 16

$$tan\ (A + B) - tan\ (A - B) = \frac{tan\ A + tan\ B}{1 - tan\ A\ tan\ B} - \frac{tan\ A - tan\ B}{1 + tan\ A\ tan\ B}$$

Reduced to a common denominator the second term becomes

$$= \frac{(tan\ A + tan\ B)(1 + tan\ A\ tan\ B) - (tan\ A - tan\ B)(1 - tan\ A\ tan\ B)}{(1 - tan\ A\ tan\ B)(1 + tan\ A\ tan\ B)}$$

which further reduces so that

$$tan\ (A + B) - tan\ (A - B) = \frac{2\ tan\ B + 2\ tan^2\ A\ tan\ B}{1 - tan^2\ A\ tan^2\ B}$$

Dividing the numerator and the denominator of the second term by $tan\ A\ tan\ B$, and substituting the cotangent for the reciprocal of the tangent

$$tan\ (A + B) - tan\ (A - B) = \frac{2\ (cot\ A + tan\ A)}{cot\ A\ cot\ B - tan\ A\ tan\ B}$$

Functions of the Sum and Difference of Angles Concluded

On account of the importance of the equations derived in this and the two preceding lessons and hence more or less separated, they are here recapitulated where they may be more easily referred to when subsequently needed.

$$sin\ (A + B) = sin\ A\ cos\ B + cos\ A\ sin\ B \qquad (11)$$

$$sin\ (A - B) = sin\ A\ cos\ B - cos\ A\ sin\ B \qquad (12)$$

$$cos\ (A + B) = cos\ A\ cos\ B - sin\ A\ sin\ B \qquad (13)$$

$$cos\ (A - B) = cos\ A\ cos\ B + sin\ A\ sin\ B \qquad (14)$$

$$tan\ (A + B) = \frac{tan\ A + tan\ B}{1 - tan\ A\ tan\ B} \qquad (15)$$

$$tan\ (A - B) = \frac{tan\ A - tan\ B}{1 + tan\ A\ tan\ B} \qquad (16)$$

$$cot\ (A + B) = \frac{cot\ A\ cot\ B - 1}{cot\ B + cot\ A} \qquad (17)$$

$$cot\ (A - B) = \frac{cot\ A\ cot\ B + 1}{cot\ B - cot\ A} \qquad (18)$$

Functions of Double and Half Angles

From the equations just given may be easily deduced the functions of angles which are of double or half the number of degrees of any given angle. The functions of

all double angles are found directly by making angles A and B equal. Then equations 11, 13, 15 and 17 become, respectively

$$sin\ 2\ A = 2\ sin\ A\ cos\ A \qquad (19)$$

$$cos\ 2\ A = cos^2\ A - sin^2\ A \qquad (20)$$

(also equal to $2\ cos^2\ A - 1$, or $1 - 2\ sin^2\ A$, by equation 1, Lesson III),

$$tan\ 2\ A = \frac{2\ tan\ A}{1 - tan^2\ A} \qquad (21)$$

$$cot\ 2\ A = \frac{cot^2\ A - 1}{2\ cot\ A} \qquad (22)$$

From equation 20 (one of its alternative forms)

$$2\ sin^2\ A = 1 - cos\ 2\ A$$

Dividing by 2 and extracting the square root

$$sin\ A = \pm \sqrt{\tfrac{1}{2}\ (1 - cos\ 2\ A)}$$

Since A is any angle one-half of it ($\frac{1}{2}\ A$) may be substituted for it, when the last equation becomes

$$sin\ \tfrac{1}{2}\ A = \pm \sqrt{\tfrac{1}{2}\ (1 - cos\ A)} \qquad (23)$$

(The sign $\pm$, *plus or minus*, always goes before an expression for square root, as either a product of *minus* and *minus* or *plus* and *plus* will give a plus product, but for any one of these functions having the sign $\pm$ before it, the function is $+$ if the angle A is less than 180°).

Also from equation 20

$$2\ cos^2\ A = 1 + cos\ 2\ A$$

and similarly as before,

$$cos\ \tfrac{1}{2}\ A = \pm \sqrt{\tfrac{1}{2}\ (1 + cos\ A)} \qquad (24)$$

The tangent being equal to the sine divided by the cosine

$$tan\ \tfrac{1}{2}\ A = \frac{sin\ \frac{1}{2}\ A}{cos\ \frac{1}{2}\ A}$$

and, expressions having just been found for these,

$$tan\ \tfrac{1}{2}\ A = \pm \frac{\sqrt{\frac{1}{2}\ (1 - cos\ A)}}{\sqrt{\frac{1}{2}\ (1 + cos\ A)}}$$

which reduces to

$$tan\ \tfrac{1}{2}\ A = \pm \sqrt{\frac{1 - cos\ A}{1 + cos\ A}} \qquad (25)$$

and, the cotangent being the reciprocal of the tangent,

$$cot\ \tfrac{1}{2}\ A = \pm \sqrt{\frac{1 + cos\ A}{1 - cos\ A}} \qquad (26)$$

Study Questions

26. Given $sin\ 45° = \frac{1}{2}\sqrt{2}$ find the sine, cosine, tangent and cotangent of 22 deg. 30 min.

27. Deduce an expression for the sine of the sum of three angles.

28. Deduce an expression for $sec\ (A + B)$.

29. Deduce an expression for $sin\ 3\ A$.

30. Given $tan\ 30° = \frac{1}{\sqrt{3}}$ find the sine, cosine, tangent and cotangent of 60 deg.

⁂

Oswego Factories Plan Big Power Merger—Plans for concentration of all water-power interests along the Oswego River are completed, according to an announcement made by George Coffing Warner, of New York, president of the Fulton Light, Heat & Power Co., Fulton, N. Y. The plan provides for supplying electrical current to operate factories which now are depending upon waterwheels for power. The project will be capitalized for more than $2,500,000.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

A young woman has asked New York police headquarters for a fireman's license; says she's been firing and oiling for three years. This generation is sure producing some mighty manly young women. Perhaps the prevailing styles in overalls will undergo a decided change. Haberdashers, please answer.

⁂

"Save the man of 40! He is more important to the community than the baby," says a high forehead. Whatcha mean, the babies can't holler? And where are we going to get those 40-year-olds 40 years from now if we frown down the infant industry? It can't be done!

⁂

This eugenics thing has been given a jolt by Prof. Coulter, of Chicago University. "Innate delicacy and common sense are causing a revulsion of feeling touching eugenics." The eugenists might turn their attention to poultry, or horses, or dogs, with good results, but humans!

⁂

There's nothing slow about Philadelphia when it can have an electric-cable explosion! Wish we could get more particulars. Was it due to a short circuit between high-voltage ammonia pipes and low-voltage superheated steam mains? Or perhaps some brute jabbed it with a needle.

⁂

Speaking of the evils of smoke pollution, it was recently said that "the functional efficiency of the visual naso-pharyngeal, pulmonary, gastro-intestinal and neural mechanisms may be disabled by constant irritation by smoke particles." Yes, and even the eyes, nose, lungs, stomach and nerves are sometimes equally affected.

⁂

Gol' darn if those Boston Power Show boosters aren't at it as if the big noise came off in January instead of Apr. 27! Wish we could go. We'd dig down to Mrs. Atkinson's first thing for a plate of beans and brown bread, and then we'd sneak up the alley to the "Bell in Hand" and have—well, we'd not get it in a plate. But mebbe these oldtime hang-outs are now ancient history? Then we'd make tracks for the old Revere House and hunt up a Commercial Engineer. Feller, you can't stump your Uncle Billy?

⁂

Mister Fra Hubbard (no relation of old Mother Hubbard) has recently been heaping praise upon the heads of Dr. Steinmetz, Samuel Insull and Henry Doherty. The Fra is some heaper when it comes to praise, but these three men deserve it, which is not always the case.

⁂

"An accident happened to a steamer shortly after leaving Habana," says a Cuban correspondent. "The next day a local paper had the following account of the occurrence:

"'Yesterday the steamer "X" left port en route for Santander and Corunia but returned just at nightfall owing to an accident to her machinery. The chief engineer informed our representative that the main steam valve had slipped and bent the low-pressure cylinder.'"

⁂

My word, old top, if you feel you have a liver, when readin' the awf'ly dry reports of meetin's in the States, you'll jolly well be refreshed by an account of a Local Government Board meetin' at home:

"The profits of the gasworks were nearly £13,000," says Mr. Ekin.

"Fiddlesticks!" says Mr. Smith, who's a sassy, not to say profane man.

Then a knowin' Johnny says the illumination power won't reduce below 15 candles.

Then Smithie says, right out, you know: "What is to be the calorific power?"

"In what?" asks old chap Ekin.

"In Board of Trade units," says Smithie. And then the whole meetin' began lawfing and chawfing— and a few tittered, Absolutely!

And then Ekin goes off his chump and says: "Board of Trade units in a gas plant! Rubbish! Sit down!"

And then—well, that's all, dear boy, but isn't it a bit of home, eh what? Quite so!

Further Operation of Large Delray Boilers†

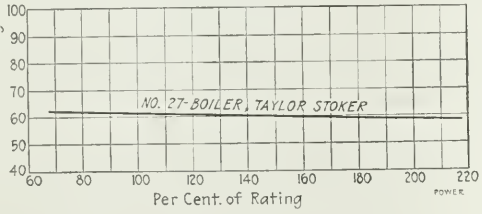
By J. W. Parker

SYNOPSIS—During two years' operation of seven of these boilers only two tubes have had to be replaced and the boilers have been ready for service 95 per cent. of the time, or 100 per cent. of the time during peak-load periods. As high as 11,000 kw. has been carried on a single boiler for over an hour.

❖

At the December, 1911, meeting of the society, Dr. S. Jacobus presented a paper* giving the results of the first performance tests on the 2365-hp. Stirling boilers at the Delray generating plant of the Detroit Edison Co. At the time of his tests three of these boilers were in service, one having been run about 18 months and the others nine months. Since that time six more of the type have been installed.

The causes which might take boilers out of commission at times when they are needed for service are being eliminated. The boiler itself need be no hazard. Fittings and flanged joints, if properly watched and followed up,



Overall Efficiency of Boiler and Furnace at Different Ratings

do not cause shutdowns. The same is true of the tubes, which are seamless. From Oct. 15, 1912, to Nov. 1, 1913, there have been but two tubes replaced in seven boilers whose average age is two years. One front tube was taken out after the discovery of a small bag next to the fire, which was found during a periodical inspection. The other was spoiled by a mishandled turbine-tube cleaner.

The plant is using about 8 per cent. of makeup water, and a sulphate scale about $\frac{1}{16}$ in. thick forms in the hot front tubes. These front surfaces are worked exceedingly hard and scale of even $\frac{1}{16}$ in. thickness may make trouble. A soft piece of mud, lodging on top of the hard scale is likely to cause a small bag. This trouble can occur only in the lower bends of the first row of tubes, where loose dirt sometimes lodges. Tube trouble will be practically eliminated by the use of pure water. The makeup water is now river water, treated with enough barium hydrate to neutralize the sulphate content. The percentage of makeup can be reduced to between 2 and 3 per cent. by avoiding the necessity of blowing down boilers. It is seriously contemplated to use distilled water for makeup. There seems to be a lack of evidence that distilled water is of itself corrosive, but to safeguard against any possible boiler corrosion, enough soft scale-forming material would be introduced into the feed water to cover the heating surface with a thin protecting scale.

†From paper read at annual meeting of the A. S. M. E.

*See "Power," Dec. 5, 1911.

Stokers

Repairs ordinarily made on the stokers are the replacement of tuyeres, dump plates, etc., which have burned out. There have been cases of sudden stoker breakdown, sometimes occasioned by the introduction of chunks of iron or wood into the stoker rams, along with the coal. Also, there have occurred once or twice, serious burnouts of tuyeres and other grate surfaces extending over an area of 5 or 6 sq.ft. In these instances the fire was banked on the side of the furnace where the trouble existed and the other half of the furnace operated to get half capacity from the boiler.

Reliability

To sum up, our experience has been this: The boilers were ready for service 95 per cent. of the time considered; they were ready 98 per cent. of the five full-load days of the week; and ready for service 100 per cent. of the time during the peak-load periods. It is to be assumed that the boilers must be down for ten days or two weeks at nine- or ten-month intervals for cleaning and a general overhauling of stokers and brickwork.

The Detroit Edison Co. is now building a power plant to contain six 20,000-kw. turbines served by 12 of these 2365-hp. boilers, which is two boilers to one turbine, with no spares, or 10,000 kw. per boiler. Although the chances of losing the capacity of any boiler by a forced shutdown are remote, they have, nevertheless, been considered. At normal full load on a given turbine unit, the two boilers will operate at approximately 191 per cent. of rating based on 10 sq.ft. of heating surface per boiler horsepower. If with six boilers running at this rating, one boiler should go completely out of commission the other five would have to carry the entire load of 60,000 kw. and thus operate at 235 per cent. of rating, which is perfectly possible. As a matter of fact, the settings and auxiliaries are being designed to allow of continuous operation at 255 per cent. of rating, which would enable three boilers to take the full load of four, that is, 40,000 kw. Very recently, one of the Delray boilers was isolated from the rest of the plant with a 15,000 kw., seven-stage Curtis vertical turbine, and over 11,000 kw. was carried for an hour without difficulty.

The overall boiler and furnace efficiency of one of the Taylor stoker-fired units is shown by Fig. 1. The curve has a gradual slope from 80 per cent. efficiency at 93 per cent. of rating, to 76 per cent. efficiency at 214 per cent. of rating. It is economical, therefore, to run as many boilers as possible at about 90 per cent. of rating when the plant load is light, and then carry the peak by increasing the rating on the boilers. This is our present practice, which is very convenient in summer when provision must be made for a sudden peak due to a thunder storm.

Fire-Room Operation

The plan is for one man to operate two stokers, and in addition, to have a head fireman in charge of from six to eight units, whose duty it is to oversee all the fires, and give assistance to any fireman who needs help. On the gage board are mounted steam gages showing the

essure at the superheater inlet and outlet and draft ges showing the air pressure under the fire, draft at the mper, and draft at the top of the combustion chamber. iere is also on this board the record dial of a CO_2 meter. ie meter itself is mounted on a gallery 15 ft. above the iler-room floor in a position central to four boilers. our samples of gas are drawn from one furnace, auto- atically mixed, and the resulting analysis is recorded iere the fireman can watch it.

A water tender stationed on a gallery at the top-drum rel feeds the boilers, but the fireman does everything ce in the way of operation. The dampers are shifted at e control point, and the throttles of the blower turbines e extended through the floor near the gage board. The okers are motor driven and one of the controllers is cated on a steel column 6 ft. away from the gage board; e other could have been brought around also, but it was ought unnecessary, since a man must walk around to e stoker on the distant side to watch it and to study s fire. The control point of the opposite boiler is lo- ted just across the aisle from the first.

The whole idea is to employ the most expert firemen d give each man control of the burning of a very large iount of coal. It is economical to employ a fine type man and pay him an expert's pay. The present first- ass fireman's pay is 40c. an hour and he is well treated to vacation and sick leave. These men are given the nefit of whatever boiler testing is done, and a force of emen is being built up that can obtain remarkable re- lts with their fires. At the same time the unit cost of ing is unusually low.

At the end of each firing aisle is mounted a large pilot eam gage. The dial is graduated in divisions of 1½ on its circumference but with no figures, and each le division registers 1 lb. per sq.in. It is found and arked at just what point on this sensitive gage the iler safety valves will lift and the steam pressure is rried accordingly. On the same gage board with the ot gage are a clock and the dial of a load indicator, erated from the switchboard gallery, indicating the ad on the entire plant in kilowatts. In handling his es, the fireman is guided first by steam requirements, shown by the pilot gage, and a steam-flow meter. The pressure under the fire and the stoker speed are con- olled by hand.

The stokers are driven by direct-current interpole otors having a speed control by field resistance of four one, and with 18 running points on the controllers. dicating dial tachometers are being installed on the oker shafts, so that the stoker speed for a given load ay be watched carefully.

As to furnace conditions, the firemen must judge by e CO_2 recorder, by the amount of air pressure neces- ry for any given boiler load, and also by the color of the ses as they pass over the first baffle and enter the top the superheater pass. A reflecting observation de- e for this is at present being tried out, which allows e fireman to look into the boiler pass from a position ar his gage board.

Automatic vs. Hand Control

As for feeding the boiler, a skillful water tender learns t to touch the feed valve except at rare intervals and en the load on the plant becomes steady, the steam flow continuous also. One automatic feed-water regulator was tried out, but was not a success, due largely to a peculiarity of this type of boiler. On account of the rapid circulation, the water in the top middle drum stands at times 2 ft. or more above that in the two outside drums, although the three are connected with water-circulating tubes as well as by steam circulators and the main boiler tubes. The water columns are piped to the center drum, there being often no indication of water whatever in the outside drums. Under these conditions it is easy for a feed-water regulator, automatically attempting to hold a constant level in the center drum, to get into difficulties whenever the demand for steam varies sharply. When the steam demand decreases slightly, the water level may fall possibly an inch, being very sensitive. If the regulator immediately opens and starts feeding more heavily, the circulation will be still further decreased, and then the water level will fall lower and the regulator feed still more heavily. The steam output of the boiler will decrease rapidly with this, until the regulator begins to close again. The steam output will now begin to increase and the water level rise also and presently close the regulator entirely; a typical "hunting" action is thus set up.

It is not desirable to substitute an automatic air and stoker control if a better CO_2 chart cannot be shown thereby. The danger is that the fireman will rely on the automatic device, rather than study conditions and control his fire intelligently. With the present hand control, excellent furnace conditions are being obtained and held. Observation of the furnace gases, as they enter the superheater pass from the top of the combustion chamber, shows that the combustion of volatile gases is entirely complete and that the operation is consequently smokeless. At the same time, the CO_2 charts show remarkably good results, 15 per cent. of CO_2 being very common, the average being about 13.5 to 14 per cent.

Good conditions are most often disturbed by the periodic dumping of the ash and refuse from the stokers. There is now being tried out a continuous dumping device, a revolving grate, which bids to be very successful.

Setting Repairs

The settings of the boilers, fired with Taylor stokers, consist simply of four walls without arches or bridge-walls. The only brick repairs necessary thus far have been the annual rebuilding of part of both front walls extending from the stoker to the mud drum of the boilers. The end walls give no trouble when carefully bonded to the facebrick of the setting.

The most educative experience with brickwork has been had with the Roney stoker settings and their furnace arches. At first we had sprung arches under each mud drum with a central wall intersecting the bridge-wall at right angles. These pulled themselves out of shape, however, and we now use a single continuous "flat arch" under the mud drum, built of firebrick shapes hung from cast-iron rail beams. For these shapes a special brick had to be made of an exceedingly loose texture obtained by mixing sawdust with the clay before molding. Upon burning in the kiln, this sawdust burned out, leaving the brick very porous.

Limitations of Boilers

As at present installed, these boilers present certain limitations to being driven at much higher rates than al-

ready obtained. First, in burning West Virginia, long-flaming bituminous coal, it is probable that at about 275 per cent. of rating the flames will reach the top of the combustion chamber, which is 28 ft. high. As soon as uncombined combustible gases get over into the superheater pass, the overall efficiency of the unit will drop, and smoke will begin.

If the boilers in future installations are set much higher another difficulty will arise, although this is not so serious. Either more stack draft must be provided, or a pressure will be developed at the top of the combustion chamber, and the brick setting at this point must be built gas-tight.

Another limitation is the drop in pressure through the superheater, the automatic check valves and the stop valve. At 210 per cent. of rating on one boiler, the drop in pressure through the superheater is 21 lb., which includes the pressure drop through the automatic check valves, but not that through the main stop valve. At 255 per cent. of rating it would be considerably more. Since the pressure on the steam mains must remain constant, a pressure must be carried on the saturated steam drums of the boiler of 21 lb. more than at the superheater outlet, when running at 210 per cent. of rating.

Effect on Tubes

As for the effect on the front tubes of the type-W boiler, of running at very high rates of evaporation, it has been found that the tubes have shown no evidence of injury due to the hard driving. One thing is certain, however, and that is these tubes must be kept clean. As previously stated, scale which ordinarily would give no trouble, has possibilities for mischief under the conditions of harder driving.

Cost of Steam and Gas Power Equipment

By A. A. Potter*

SYNOPSIS—A table of equations deduced from manufacturers' quotations for a large list of power-plant equipment. The prices are all f.o.b. at the factory.

As a rule, selling prices of machinery are carefully guarded by manufacturers. The author, finding it necessary to use such prices very often for preliminary estimates, sent out letters to several hundred manufacturers, asking for net selling prices. The majority of the companies responded with confidential price lists. These lists were carefully tabulated and plotted, and it is hoped that the equations deduced from these plots may prove of value to others. The complete data, including tables and plots, will probably be published as a bulletin of the Engineering Experiment Station of the Kansas State Agricultural College.

The equations in the table are arranged in the alphabetical order of the machinery for which prices are given. The prices are f.o.b. at the factory, and do not include erection costs. There are many varying factors entering into erection costs, so that it is impossible to give general estimates which may be regarded as accurate. Some manufacturers quoted the following erection costs for high-speed engines:

Size of Engine, Hp.	Approximate Erection Cost in Dollars
75	125 to 150
100	150 to 200
150	200 to 300
300	300 to 400
450	400 to 450
600	400 to 600

Prof. C. H. Benjamin, in his book on the "Steam Engine," gives the following formulas for the costs of engine settings:

1. Setting for high-speed engines. Cost in dollars = 50 + 0.75 (horsepower).

2. Setting for low-speed engines. Cost in dollars = 500 + 1.3 (horsepower).

Settings for water-tube boilers vary from $400 for a 100-hp. boiler to about $650 for a 600-hp. boiler.

In the case of internal-combustion engines, the erection will vary from 7 to 15 per cent. of the total cost of the engines. The erection cost of large engines may be as low as 3 per cent. of the cost of the engine.

Difficulty was experienced in developing an equation for the cost of stokers which would be applicable over a wide range, as the size of stokers for the same boiler horsepower varies greatly with the fuel to be handled, the available draft, and other conditions. Also, in the case of underfeed stokers which include a forced-draft equipment, the cost depends on the number of boilers. Thus a quotation of $1055 was given by one concern for an underfeed stoker to be used in connection with one 125-hp. fire-tube boiler; $1793 for an equipment suitable for two boilers of the same size, and only $6300 in the case of eight boilers. A manufacturer of front-feed stokers quotes $975 for a stoker equipment for one boiler, and $1680 for an equipment for two boilers. The equations apply very nearly to equipments of four stokers, or to a lesser number.

The prices in the case of condensers are based on a cooling-water temperature of 60 deg. F., the equations are developed with reference to the pounds of steam condensed per hour.

The prices for internal-combustion engines include standard equipment. This in the case of gasoline engines consists of a battery, gasoline tank, water tank or circulating pump, muffler, and all pipes and fittings needed for the ordinary installation. With oil engines, oil pumps, heating lamps and mufflers are supplied. Also with an internal-combustion engine above 25 hp. self-starting devices are usually included.

The prices on oil engines include such internal-combustion engines as are suitable for burning very heavy oils. The cost of oil engines suitable for oils of 39 deg. Bé., or lighter, does not differ more than a few per cent. from that for gasoline engines.

The capacity of producers is given in horsepower, this being based on a producer efficiency of 75 to 80 per cent., and 10,000 to 11,000 B.t.u. per brake horsepower per hour, as the term producer horsepower has no definite meaning unless it is based on the B.t.u. consumption of the internal-combustion engine to which the gas is supplied. Some manufacturers of gas producers have aban-

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TABLE OF COSTS OF STEAM AND GAS POWER-PLANT EQUIPMENT

Name of Apparatus	Type	Capacity	Equation of Cost in Dollars
r compressors	Single cylinder, belt-driven	Up to 4000 cu.ft. per min.	52 + 1.95 × cu.ft.
	Duplex, belt-driven	Up to 850 cu.ft. per min.	316 + 1.675 × cu.ft.
	Compound, belt-driven	Up to 550 cu.ft. per min.	3.1 × cu.ft.
	Single cylinder, steam-driven	Up to 350 cu.ft. per min.	231 + 2.32 × cu.ft.
	Duplex, steam-driven	Up to 600 cu.ft. per min.	460 + 2.55 × cu.ft.
	Compound, steam-driven	Up to 500 cu.ft. per min.	71.25 + 4.025 × cu.ft.
oilers, steam	Vertical, fire-tube	Under 20 hp.	49.2 + 6.66 × hp.
	Submerged tubes, 100 lb. per sq.in. or less	20 to 50 hp.	116.1 + 3.35 × hp.
	Full length tubes; 100 lb. per sq.in. or less	Up to 50 hp.	51.5 + 3.62 × hp.
	Horizontal, fire-tube cylindrical, multi-tubular, 100 lb. per sq.in. or less	Up to 200 hp.	64 + 4.14 × hp.
		Up to 100 hp.	5.8 × hp. — 20
		100 hp. to 225 hp.	211 + 3.35 × hp.
	Portable locomotive	Up to 100 hp.	121 + 5.68 × hp.
	Vertical, water-tube, pressures over 125 lb. per sq.in.	100 to 500 hp.	912 + 6.28 × hp.
	Horizontal, water-tube, pressures over 125 lb. per sq.in.	100 to 600 hp.	149 + 8.24 × hp.
ondensers	Barometric (28-in. vacuum)	Up to 30,000 lb. of steam per hr.	1055 + 0.112 × (lb. steam cond.)
	Jet condensers	Up to 30,000 lb. of steam per hour; 28-in. vacuum	1176+0.1138 × (lb. steam cond.)
		26-in. vacuum	116 + 0.0591 × (lb. steam cond.)
	Surface condensers	Up to 35,000 lb. of steam per hr.; 28-in. vacuum	1630+ 0.2038 × (lb. steam cond.)
		Up to 30,000 lb. of steam per hr.; 26-in. vacuum	413 + 0.1015 × (lb. steam cond.)
conomizers	Number of tubes 32 to 10,000, heating surface per tube = 12 to 13 sq.ft.	Capacity in lb. of water per tube = 60 to 70	
		Economizer alone	$8 to $10 per tube
		Economizer erected.	$12 to $15 per tube
ngines, internal combustion	Gas engines	Up to 300 hp.	33.6 × hp. — 115
	Gasoline engines, hit-and-miss governor	Up to 100 hp.	141 + 24.8 × hp.
	Gasoline engines, throttling governor.	Up to 75 hp.	300 + 36.1 × hp.
	Oil engines	Up to 400 hp.	63.8 × hp. — 316
	Producer gas engines, American mfg.	Up to 300 hp.	400 + 33.5 × hp.
ngines, steam	Simple,		
	Throttling governor, slide valve, vertical	Up to 70 hp.	63.5 + 17.5 × hp.
	Throttling governor, slide valve, horizontal,		
	Upper limit in cost	Up to 70 hp.	107 + 13.3 × hp.
	Lower limit in cost	Up to 200 hp.	80 + 5.81 × hp.
	Simple,		
	Flywheel governor, piston or balanced slide valve, horizontal	Up to 500 hp.	386 + 6.69 × hp.
	Automatic cut-off, single valve, vertical	Up to 30 hp.	164 + 9.53 × hp.
		30 to 150 hp.	372.5 + 9.55 × hp.
	Flywheel governor, Corliss non-releasing valve, horizontal	Up to 600 hp.	1100 + 8.94 × hp.
	Corliss governor and valves, horizontal	Up to 400 hp.	1040 + 8.45 × hp.
		300 to 900 hp.	730 + 9.1 × hp.
	Flywheel governor, multiple flat valves	Up to 400 hp.	685 + 7.69 × hp.
	Cross compound,		
	Ball governor, single-valve, horizontal	Up to 330 hp.	735 + 8.0 × hp.
	Ball governor, single-valve, vertical	Up to 200 hp.	750 + 10.4 × hp.
	Flywheel governor, multiported valves, horizontal	Up to 600 hp.	1100 + 9.62 × hp.
	Shaft governor, Corliss non-releasing valves, horizontal	Up to 600 hp.	2015 + 9.74 × hp.
	Tandem compound,		
	Flywheel governor and slide valves, horizontal	Up to 400 hp.	559 + 8.83 × hp.
	Flywheel governor and slide valves, vertical	Up to 140 hp.	610 + 12.7 × hp.
	Flywheel governor, Corliss non-releasing valves, horizontal	Up to 300 hp.	1295 + 10.79 × hp.
	Flywheel governor, multiple slide valves	Up to 500 hp.	1010 + 7.65 × hp.
ans and blowers	Sizes 70 to 140 in.		6.25 × (size in inches)^3.
ed-water heaters	Open	Up to 1500 boiler hp.	114.5 + 0.3787 × hp.
		1500 to 3000 boiler hp.	326 + 0.237 × hp.
	Closed	Up to 3000 boiler hp.	40 + 0.72 × hp.
enerators, electric	Direct current (voltage 110-250), belted	Up to 7 kw. (1400 to 2300 r.p.m.)	21.1 + 28.5 × kw.
		10 kw. to 300 kw. (600 to 1400 r.p.m.)	10 × (kw.) — 9
	Direct-connected	Up to 300 kw. (100 to 350 r.p.m.)	313.3 + 10.93 × kw.
		300 to 1000 kw. (moderate speed)	12.08 × (kw.) — 383
	Alternating-current, belted	Up to 300 kv.a. (600 to 1800 r.p.m.)	81 + 9.723 × kv.a.
	Direct-connected	Up to 300 kv.a. (200 to 300 r.p.m.)	375 + 7.477 × kv.a.
		250 to 2500 kv.a. (100 to 250 r.p.m.)	2413 + 4.69 × kv.a.
otors, electric	Direct-current, belted; small sizes	Up to 1.5 hp. (1400 to 2500 r.p.m.)	18.53 + 42.37 × hp.
		5 to 30 hp. (1000 to 1800 r.p.m.)	53.3 + 12.4 × hp.
		30 to 100 hp.—Upper limit (500 to 800 r.p.m.)	191.7 + 10.94 × hp.
		Lower limit—(800 to 1000 r.p.m.)	213 + 8.264 × hp.
	Variable speed	Up to 10 hp.—Upper limit.	64.1 + 36.786 × hp.
		Lower limit.	69.2 + 10.56 × hp.
	Alternating current:		
	Single-phase (110-220 volts)	Up to 25 hp. (1200 to 1800 r.p.m.)	25 + 11.75 × hp.
	Belted; polyphase induction	Up to 130 hp. (1200 to 1800 r.p.m.)	116 + 4.72 × hp.
	Variable speed	Up to 25 hp.	60.7 + 7.15 × hp.
		35 to 60 hp.	157.6 + 3.573 × hp.
roducers, gas	Suction	Up to 300 hp.	252 + 14.2 × hp.
	Pressure	Up to 300 hp.	860 + 15.15 × hp.
roducer plants, gas	Suction	Up to 200 hp.	570 + 46.5 × hp.
umps	Boiler feed		
	Single-cylinder, piston pattern	Up to 6000 gal. per hr.	17.8 + 0.2586 × (gal. per hr.)
		6000 to 27,000 gal. per hr	106.8 + 0.011045 × (gal. per hr.)
	Duplex, piston pattern	Up to 29,000 gal. per hr.	585 + 0.0115 × (gal. per hr.)
	Single-cylinder, outside-packed, plunger pattern	Up to 24,000 gal. per hr	0.034 × (gal. per hr.)
	Duplex, outside-packed plunger pattern	Up to 49,000 gal. per hr.	0.042125 × (gal. per hr.)
	Centrifugal		
	Horizontal, low-pressure, single-stage	Up to 14,000 gal. per min.	52 + 0.05525 × (gal. per min.)
	Horizontal, high-pressure, single-stage	Up to 5000 gal. per min.	61 + 0.0868 × (gal. per min.)
		5000 to 20,000 gal. per min.	210 + 0.0567 × (gal. per min.)
	Horizontal, high-pressure, multi-stage	Up to 2200 gal. per min.	117 + 0.233 × (gal. per min.)
	Vertical, low-pressure, single-stage	Up to 20,000 gal. per min.	60 + 0.05575 × (gal. per min.)
	Vertical, high-pressure, single-stage	Up to 20,000 gal. per min.	50 + 0.0865 × (gal. per min.)
	Vertical, high-pressure, multi-stage	Up to 1100 gal. per min.	125.7 + 0.27 × (gal. per min.)
	Geared power		
	Single cylinder	Up to 20,000 gal. per hr.	90 + 0.0316 × (gal. per hr.)
	Single-acting, triplex	Up to 83,000 gal. per hr.	56 + 0.03867 × (gal. per hr.)
	Double-acting, triplex	Up to 89,000 gal. per hr.	195 + 0.0148 × (gal. per hr.)
	Rotary force pumps	1200 to 20,000 gal. per hr.	8 + 0.0117 × (gal. per hr.)
	Wet vacuum pumps	Up to 13,000 gal. per hr.	18 + 0.01435 × (gal. per hr.)
		13,000 to 50,000 gal. per hr.	14 + 0.00863 × (gal. per hr.)

TABLE OF COSTS OF STEAM AND GAS POWER-PLANT EQUIPMENT—Continued

Name of Apparatus	Type	Capacity	Equation of Cost in Dollars
Power-house piping	Water	1000 to 20,000 gal. per hr.	1000 +0 .2 × (gal. per hr.)
Stokers	Chain-grate	100 to 300 boiler hp.	86 + 4.28 × (hp.)
		300 to 500 boiler hp.	434 + 3.1 × (hp.)
	Front-feed	100 to 660 boiler hp.	312 + 3.015 × (hp.)
	Under-feed	Up to 600 boiler hp.	379 + 2.785 × (hp.)
Superheaters	200 to 750 boiler hp		
		100 deg. of superheat	165 + 2.578 × (hp.)
		200 deg. of superheat	52 + 3.466 × (hp.)
		300 deg. of superheat	40 + 4.28 × (hp.)
Transformers	Air-cooled	Sizes up to 3000 kv.a.	439 + 1.467 × kv.a.
	Oil-cooled	Sizes up to 30 kv.a.	
		25 cycles	52.9 + 8.1 × kv.a.
		60 cycles	26 2 + 6.25 × kv.a.
		Sizes 30 to 100 kv.a.	
		25 cycles	157 + 4.68 × kv.a.
		60 cycles	119.5 + 3.57 × kv.a.
	Water-cooled	Sizes up to 1000 kv.a	181 + 1725 × kv.a.
		1000 to 3000 kv.a.	805 + 1099 × kv.a.
Turbines, steam	Reaction type:		
	Turbine and generator	500 to 5000 kw.	3335 + 13.33 × kw.
		5000 to 10,000 kw	17,500 + 10.5 × kw.
	Impulse type:		
	Turbine alone	Up to 50 hp.	171.5 + 10.7 × hp.
		50 to 400 hp.	10.74 × hp. — 54
	Turbine and generator	Up to 40 kw	304.2 + 36.78 × kw.
		25 to 350 kw	30.4 × kw. — 100
		1000 to 10,000 kw.	8106 + 11.34 × kw.

doned the horsepower rating, and rate their producers in pounds of coal, which is the same as the B.t.u. basis.

The prices given for generators and motors apply to standard speeds. Of the many variables which must be taken into consideration in connection with prices on dynamo-electric machinery, speed is the most important, as the amount of copper in a machine (the voltage remaining constant) is determined by the speed for which it is designed.

The prices for transformers are for voltages of 1100 and 2200. The increase in cost for higher voltages, above that for 1100 and 2200 volts is about as follows:

	Per Cent.
6,600 volts	2.5
11,000 volts	7
22,000 volts	18
44,000 volts	40

It is impossible to give the cost of switchboards in the form of an equation, as the requirements are different for each individual plant in the matter of circuits, protective devices, instruments, etc. There is also a great variation in the cost of electrical-measuring instruments of the same capacity.

Oxyacetylene Boiler Welding*

By Henry Cave†

SYNOPSIS—With particular reference to boiler welding the author gives his views as to why the oxyacetylene process is not more in use and his belief in its possibilities. He then proposes a "Three-License System" as a safeguard against dangerous or unreliable work.

Very little oxyacetylene welding has been done on tension parts of boilers and other pressure containers. This is particularly true of boilers that come under restrictions imposed by federal, state, civic or insurance regulations. The writer commends this condition, and heartily favors increased restrictions, but believes that they should be based upon principles other than those now in force.

After six years' experience in practical welding with a large number of men on a wide variety of work, and on a large number of tensile and other tests on samples prepared under various conditions, the writer is convinced that welds can be made from the ordinary steel of commerce with approximately the strength and with a fair proportion of the ductility of the original metal, if the work is carried out under certain conditions not difficult to obtain. Therefore, he believes that the development of the oxyacetylene industry is being retarded by the nature of the restrictions imposed. It has been proved repeatedly that welds can be made so strong that the test bar will break outside of the zone of the heat, showing that the weld is at least as strong as the original metal. Many tests have been made in which samples broke in the weld (and in a number of cases outside) with a load varying only by a small percentage from that obtained by pulling samples of the unwelded material, and the welds were ground off to the uniform section.

Even if only one tested weld had shown a strength nearly equal to that of the original metal, it would indicate that it is possible to obtain such a result with the process under the right conditions. These conditions have been found to be:

(1) A torch equipment that can be adjusted to give a uniform flame under all conditions of temperature, burning the acetylene with the least proportion of oxygen that will give the clear outline of the high-temperature flame (interior cone). If any more is supplied, the additional oxygen must pass through the high-temperature flame in its uncombined state, and, coming in contact with the molten metal, produce practically instantaneous oxidation, which cannot help but affect the strength. As an oxidized weld will be brittle and may be weak, consideration should be given to the mixture produced by the torch. Obviously impurities in either of the gases may produce weak welds, and this feature should also be considered.

Other considerations are: The effects that the heat reflected back on the torch head may have on the mixture, which is dependent upon the way the gases are mixed together, the expansion and contraction of the orificies produced by the varying temperatures, which necessarily

*Abstract of a paper entitled "The Oxy-Acetylene Process as Applied to Steel Welds in Tension," presented before the New York section of the American Institute of Steam Boiler Inspectors, Nov. 28, 1913.

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vary the velocity of the propelling fluid, and the uniformity of action of the reducing valves and regulators controlling the pressure of both the oxygen and the acetylene.

(2) The second consideration is that of the operation of the torch. Unfortunately, using the torch appears to require little skill. The novice thinks the movements of the torch are solely to spread the heat, whereas they are also to spread the metal. The ideal weld in steel is made by spreading each drop as thin as possible over a large area, being sure that the metal over which it is spread is hot enough for the two to flow together and that the edges of the drop, instead of being rounded like a drop of water on a greasy plate, will spread out as if the drop had been placed on a piece of blotting paper. It is also necessary to blow away the particles or films of oxide, which are readily distinguishable as they are much brighter than the metal.

The adjustment and skill necessary to carry this out can be obtained only by considerable experience with the torch. Other metals require other treatments, which also can only be learned by experience.

(3) The third consideration is the material, fluxes and methods used. If the adding material (melt bar or welding wire) used is of a lower tensile strength than the metal being welded, and variations in other properties occur, and the material is welded in and left in its original condition, the weld cannot be as strong as the original metal. If the test of the weld shows a higher tensile strength than the test of the adding material a change has taken place in the material, and this generally results detrimentally to some other property, and even though the strength is increased it is questionable whether this is desirable.

In taking the strength of a welded sample that has been tested, the comparative strength of the weld, if the fracture occurs at that point, should be taken as being proportional to the strength of the adding material and not to the strength of the original bar. Even though originally the same, a true comparison may not be obtained as the original material may change in strength after being heated. The strength may be lowered or raised by heat treatment. This depends upon the history of the material as to fatigue, method of manufacture (such as cold or hot rolling) and heat treatment.

Steel takes its structure from the highest temperature to which it has been raised. This structure varies on the rising temperature only. Unfortunately, the structure produced by the molten temperature is very coarse, which, though it may mean a greater strength, will mean a lower ductility and increased brittleness. This has to be considered in welding, but the welding is not responsible for it. The metal, whether welded or not, if brought to a high temperature, would be equally affected. Therefore, in comparing the strength of the weld with the original material, or considering the actual efficiency of the weld, corresponding heat treatment should be given to both the original and the welded piece. To get the best result, the heat treatment should be given after the weld is finished.

We have recently found that using a flux in steel welding will increase the strength of the weld at least 6 per cent. if conditions warrant. We assume that the poorer the conditions under which the work is done, the greater proportionate effect will the flux have in making a weld of any size, particularly in boiler work. It is always necessary to study the effect of shrinkage and the internal strain so produced, and particularly in repair work.

Three-License System

The writer strongly recommends that a system of examination be developed similar to that now in force in fire-insurance circles, and if the equipment is found satisfactory, it should be licensed to carry out work on vital parts in tension, and arrangements should be made that no equipment not so licensed should be allowed to do such work.

Not only should the torch be considered, but the whole equipment to be used. The manufacturers who have the best interest of the process at heart would gladly pay the expense of the investigation in connection with their individual equipments.

Owing to the low price at which welding equipments can now be purchased, nothing is to prevent an inexperienced operator from obtaining an equipment, and using it on boilers or other vital parts. Thus a disaster might occur that would detrimentally affect, if not prohibit, the use of the process on this class of work, thus also injuring those capable of giving satisfactory results. This is not likely to occur in states having inspection laws. The effect, however, in those states, should a disaster occur in the states not having inspection laws, would still be detrimental to the progress of the industry as such things are given snap judgment which does not consider the condition under which the work was carried out.

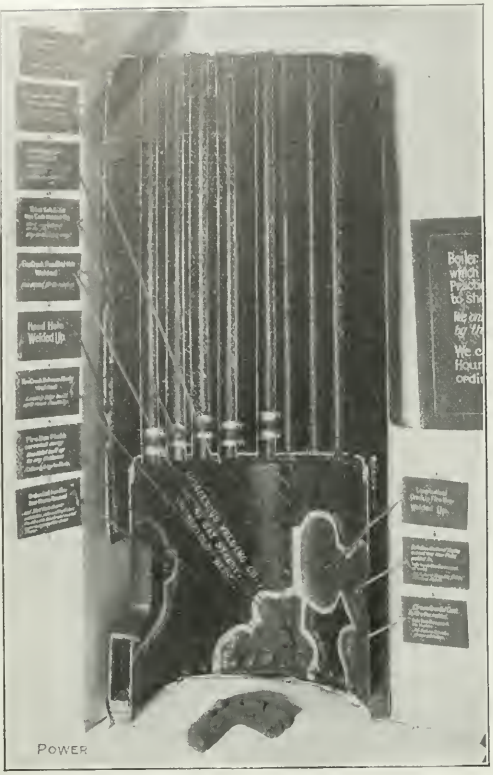
For the sake of the industry, therefore, no one should be allowed to weld on a boiler, irrespective of the type of work, throughout the whole of the United States, who has not passed an examination as to his ability to make a strong weld with a licensed equipment. It would seem that with these two licenses safety might result. Unfortunately, however, the operators, owing to the fact that a development of this sort generally attracts those who have not learned a trade, generally do not have any knowledge as to where and how and under what conditions their skill should be used.

Even though they can make a weld strong enough to pass the examination, they cannot judge as to the best materials to be used, the heat treatment, if any, necessary; they do not understand the structure of steel, and frequently could not decide which was a tension or a compression member, not having any knowledge of the structure of boilers. For success, such general knowledge is required, and, therefore, the concern using the licensed equipment and licensed operator should also be examined as to the technical ability available to determine such factors, and should be licensed accordingly.

These three licenses together would form what the writer has christened "The Three-License System," and it is his opinion that no work should be allowed to be done on boilers without the three licenses. All other restrictions should be removed, and if the concern having the Three-License System felt that it could weld such structures as steam boilers, using welds instead of rivets, without risking its license it should be allowed to do so. The license of the operator and the concern would check one another as neither of them would want to risk losing the license. Thus the industry would be placed on a sound basis which would result in a remarkable development in every direction.

Not only would the industry be benefited, but the

[illegible] would be improved and its cost reduced. The writer believes that 15 and possibly 25 per cent. of the [illegible] experienced with boilers is traceable to the riveted seams and conditions incidental to their design and manufacture.



BOILER WITH TYPICAL OXYACETYLENE WELDS, CUT THROUGH WITH OXYGEN JET

Cards read: "Circumferential and Radial Cracks in bend of upper tube plate flange"—"Cracked Tube Plate Bridges Welded"—"Hand Hole Enlarged to the Limit. Welded up and original sized hole cut with oxygen cutting torch"—"Tubes Safe Ended New Ends Welded On"—"Fire Crack from Rivet Hole Welded. Hole welded for reriveting"—"Handhole Welded Up"—"Fire Crack Between Rivets Welded. Landing edge built up to renew calking"—"Firebox Plate Corroded Away. New metal built up to any thickness. Calking edge built up"—"Broken Cast Iron Fire-Door Frame Removed, and steel plate frame welded in. "Longitudinal Crack in Firebox Welded Up"—"Defective Section of Firebox Cut Out and New Plate Welded In"—"Circumferential Crack in Firebox Welded."

The oxyacetylene process is being unfairly treated by those in position to make regulations controlling its use. In one state having boiler inspection, hand or forge welding is allowed on tension surfaces, limiting only the percentage of strength to be used in figuring the efficiency of the joint; whereas use of the oxyacetylene torch is entirely prohibited under any condition for welds in tension. Yet with hand or forge welding the only assurance of satisfactory results is the reputation of the man doing the work, who may not have been proved competent. His reputation may be based on his being a good all-around workman and having had few or none of his welds break, which may be because they were favorably located. Conditions such as the nature of the material used may influence the strength of the weld regardless of the skill of the workman. An inspector cannot determine whether the weld is good or not, even though he may have seen it made.

With the oxyacetylene process, however, satisfactory evidence may be obtained of the skill and reliability of the workmen, the possibility of success with the equipment having been proved. No uncertain variations of this are likely. There is, however, the additional advantage that an inspector could watch every movement of the operator and see that the weld was made completely through the piece, and that the metal was spread satisfactorily and could consequently determine the quality of the weld. The unjust discrimination against oxyacetylene welding in favor of forge welding, the strength of which cannot be judged without destructive tests, arises from forge welding being an old process.

Unfortunately, statements and reports have been made by men prominent in other fields regarding tests and other features of oxyacetylene welding which are generally taken as proved facts; these have seriously interfered with the development of the process.

A prominent European expert in that art recently declared that oxyacetylene welding should not be used in vital parts of containers until the strength of the weld can be determined without destroying it. The writer holds this to be practically an impossibility. That which makes such a thing desirable for the oxyacetylene weld, makes it equally so for other joints, which in years of use have not developed the means.

In the writer's opinion the strength of an oxyacetylene weld and the uniformity of results obtained are entirely a matter of satisfactory and uniform conditions.

New Jersey N. A. S. E. Visits

The first of the visits of the Visiting Committee of the New Jersey State Association of the N. A. S. E. was made to Jersey City No. 1 Association, Saturday evening, Dec. 20. The meeting was exceptionally large, there being about 200 present. State President Jenkinson presided.

Among the speakers was J. D. Taylor, Secretary-Treasurer of the Life and Accident Department, who told of the benefits and growth of the department. National President Coe, who followed, stated that the growth of the association was more than meeting expectations, and that he hoped to see 50 new associations organized this year. National Conductor J. J. Reddy, of Jersey City, told of the value the association had been to him and thanked those present for their support in electing him to office.

Charles H. Bromley, Chairman of the New Jersey State Educational Committee, stated that the line of demarcation between the mechanical and power-plant engineer was fast becoming less apparent. He outlined recent developments in plant practice and clearly showed that to meet the demands expected of him, the engineer must apply himself more closely to his art than was necessary in the days gone by. Sincere coöperation with the National and State Educational Committees was urged as vitally essential to the growth and prestige of the association.

John J. Calahan, Chairman of the Convention Committee that is arranging for the convention to be held in Jersey City next May, announced that the entire Elk's Hall building had been reserved and one of the biggest conventions and exhibits planned. He paid a high tribute to the convention committee of Newark No. 3 Association for its pioneer work and for the precedents it had established. "Bill" Cronnelly, one of the oldest members who has been active in engineering affairs since a time ante-dating the Civil war, thanked the young men for their work in making the association what it is.

F. A. La Pointe, of Hoboken, told of the proposals for lighting some of the Hudson County highways with current supplied by a new county-owned plant or by enlarging one of the two plants serving county institutions.

Among others who made interesting remarks were State Deputy Martin J. Hickey, E. W. Sears and George R. Starr.

A similar meeting was held by Newark No. 3 Association, Monday evening, Dec. 22. Refreshments and talent made the evenings enjoyable.

These visits will be continued throughout the season, the places and dates being as follows: Jan. 5, Hoboken; Jan. 10, Atlantic City; Jan. 20, Elizabeth; Feb. 2, Trenton; Feb. 12, Newark No. 8; Feb. 25, Paterson; Mar. 6, Plainfield; Mar. 20, Perth Amboy; Apr. 11, Passaic.

Verdict on Staten Island Boiler Explosion*

On December 16 was held the coroner's inquest into the cause of the boiler explosion which occurred at the Livingston plant of the Richmond Light & Ry. Co., on Oct. 21 last, and resulted in seven deaths. The lapse of nearly two months between the date of the explosion and that of the inquest is explained by the desire of the coroner to get at all the facts in the case. Unlike most investigations of its kind the inquest was conducted in an intelligent manner, the coroner and district attorney being represented in technical matters by C. G. Armstrong, consulting engineer for the city, and by Otto H. Klein, director of the Standard Testing Laboratory. The latter made a microscopic examination and test of the metal in the head and found an ultimate tensile strength of 55,000 lb per sq.in.; also, the microphotographs failed to disclose any unusual condition in the structure of the metal. In view of testimony which developed during the hearing it is to be regretted that he did not subject the metal of the stays to similar tests.

It will be remembered that the boiler was of the vertical type and that failure occurred in the bottom head in almost a perfect circle at the "knuckle" or section where the curvature changes to form the flange.

Both Mr. Klein and Mr. Armstrong gave as their opinion that the failure was the result of breathing of the head which, being intensified at this section of greatest curvature, set up small annular cracks. Mr. Armstrong further testified that there was some pitting, but that the metal was not wasted away to any great extent. These opinions subsantiate those expressed in "Power" at the time.

Messrs. Nixon and Fitzgerald who inquired into the accident for the Public Service Commission believed the explosion to have been due to defective crowfeet stays between the head and lower tube-sheet; several of these having been welded. Mr. Fitzgerald testified that he had noted several welds in which the metal had been burnt and Mr. Nixon spoke of some of the crowfeet presenting a spongy appearance. Both spoke of the bad condition of the boiler plant in general.

While the opinions of Messrs. Armstrong and Klein, on the one hand, and Nixon and Fitzgerald, on the other, appear divergent, it is probable that both are correct. Mr. Armstrong and Mr. Klein are right in their contention that the head, if in good condition, should have supported the pressure at a reasonable factor of safety without staying. Substitution in the formula for convex heads as prescribed by the Board of Supervising Inspectors, U. S. Steamboat Inspection Service, also the Massachusetts Boiler Rules, will show this to be true. The stays in this boiler were primarily to support the flat tube-sheet although they may be considered to have afforded additional support to the head. What probably happened is this: The head itself became weakened at the point of failure through cracks set up by the breathing action described and possibly by some pitting or grooving until a stage was reached where it was dependent upon the stays for support. These being in a defective condition, gave way and the explosion resulted.

Most of the testimony pointed toward insufficient and incompetent operation. The superintendent had formerly been a lineman and two former chief enginers testified that one of their reasons for leaving was his interference with the operation of the steam end of the plant. The present chief engineer a few years ago was a motorman and his entire experience as an engineer had been gained at this plant. He had received his engineers' license about two years ago and had been in charge for about four months when the explosion occurred. Unfortunately at the insistence of the company's lawyer he was not permitted to answer some questions which might have thrown more light on the operation of the plant.

The man who was directly in charge of the repairs and inspection of the boilers had previously been a general handy man around the boiler room and received $3 a day for his services. He testified that he had internally examined the boiler on Sept. 27 and had looked over the stays, but had paid no particular attention to the head.

On the day of the accident the boiler had been blown down, filled with clean water and the fire started under it about 3 p.m. It had been up to pressure and cut in on the line only a few minutes when the explosion occurred. The man who cut in the boiler failed to put in appearance to testify, as did also the inspector from the police department; although it is doubtful if the latter would have thrown much light on the subject as he had tested the boiler eleven months previous to the explosion and this was not an internal inspection.

Mr. Shaw, chief inspector of the Travelers Insurance Co., testified that his company had previously held the boiler insurance, but owing to the general depreciation of the boiler plant and the attention it received, had refused to renew the policy when it expired last April. His company still held a liability policy with the power company, however. A letter was offered in evidence to show that the Maryland Casualty Co., which subsequently took over the risk, had made an external examination a short time prior to the accident, but there appears to have been no internal examination except the very superficial inspection by the power company itself.

In view of the foregoing evidence the jury arrived at a verdict which was in substance as follows:

That the explosion occurred while the boiler was under normal pressure as a result of a weakened condition of the lower head due to probable annular cracks and pitting at the section of failure and to defective stays.

While unable to find any one person criminally negligent to the extent that they could be successfully prosecuted, the jury in its verdict severely censured the management for inadequate maintenance and inspection of the boiler plant and for employing incompetent help without previous experience. It was further recommended that steps be taken to compel the management to install sufficient boiler capacity to permit boilers being taken out of service at regular intervals for inspection and repairs.

As an appendix to the verdict the jury recommended that the boiler inspection be taken out of the hands of the police department and placed in some department having the necessary experienced help to adequately inspect all boilers coming under its supervision.

*See "Power" for Oct. 4, 1913.

Montana Had No Boiler Explosions or Accidents in 1913

According to the recent annual report of Percy L. Brown, boiler inspector of the state of Montana, there was no boiler explosion or accident or injury to persons in charge of them in that state during the year ending Nov. 30.

During the year the department inspected 2260 boilers and condemned 21. Referring to the increased work, Mr. Brown remarks: The state is becoming more thickly settled and what was once a rolling prairie is now dotted with traction engines. They are now scattered from the northern to the southern boundaries of the state and from the far west to the prairies of the east, and are the most hazardous, arduous and expensive branch of the work of the department and will continue to be such until the many miles of prospective railroads are built."

Battleship "Vermont" Disabled at Sea

More than 400 miles east of Cape Henry the battleship "Vermont," on Dec. 17, crippled so badly as not to be able to proceed under her own power, was being towed toward Hampton Roads by her sistership, the "Delaware." Besides having her starboard main shaft broken and several of her compartments flooded on Dec. 11, the "Vermont" on Dec. 17 had some of the holding rivets on the port truss carried away. At the Brooklyn Navy Yard it was said that the ship must be without the use of her second engine.

The "Delaware" was reported as making about 3.7 knots. Previous to the last trouble aboard, the "Vermont" was making 8 knots under her own steam, with the "Delaware" and the colliers "Orion" and "Jason" close by.

The first accident occurred on Dec. 11, when at 3:45 o'clock the mainshaft snapped. Rear-Admiral Badger ordered a diver to go down and ascertain the extent of the injuries. He afterward sent a radiogram to the Navy Department, stating that the skin of the ship and the propeller strut gave no evidence of injury, and there was little cause for alarm.

From the scant description on which the mechanical experts at the Navy Department base their judgment, the belief is that the vessel's stern tube shaft must have been broken in the first place and that the auxiliary shaft has now

collapsed to necessitate the towing of the vessel. The damage to the port truss, or frame, would account for the flooding of the compartments, and the bulkheads have probably been closed to confine the spread of the water in the hold. This report is taken from the columns of the daily press. The "Vermont" reached the Portsmouth (Va.) Navy Yard on Dec. 20.

OBITUARY

John B. Calvin, chief engineer, with the Grand Union Tea Co. for 22 years, died Dec. 18 at his home, 458 Van Buren St., Brooklyn, N. Y., from pneumonia, after a week's illness. He was born in Brooklyn 54 years ago, was a member of Ridgewood Lodge, F. and A. M.; Orient Chapter, R. A. M.; Damascus Commandery, K. T.; Kismet Temple, A. A. O. N. M. S., Welcome Council, R. A.; the National Association of Stationary Engineers and the Modern Science Club He leaves a widow, Gertrude Gilbert; four sons, Chester, Irving, James and John; two daughters, Adrienne and Gertrude, and a sister, Mrs. Robert Burns, of Manhattan. Funeral services were held at his late home Dec. 21, the Rev. Gurdon H. Eggleston, of the Greene Avenue Presbyterian Church, officiating. Mr. Calvin was a man of genial personality and had won a host of friends who will sincerely regret his sudden death.

SOCIETY NOTES

The regular monthly meeting of the New York Chapter, American Society of Heating and Ventilating Engineers, was held in the Engineering Societies Building, 29 West 39th St., New York, on Monday evening, December 15, with Vice-President J. I Lyle in the chair. The topic of discussion for the evening was on "Atmospheric Conditions in Printing Establishments," and was presented by W. S. Timmis.

On Friday evening, Jan. 9, at 8:15, at the Engineering Societies Building, 29 West Thirty-ninth St., New York City, the American Society of Mechanical Engineers will hold a joint meeting with the American Institute of Electrical Engineers and the New York Section of the American Electrochemical Society. Dr. C. O. Mailloux will preside. The main topic will be "The Power Problem in the Electrolytic Deposition of Metals." The program: "The Limitations of the Problem," Lawrence Addicks, A. E. S.; "The Mechanical Side of the Problem," H. E. Longwell, A. S. M. E.; "The Electrical Side of the Problem," F. D. Newbury, A. I. E. E. The papers will be illustrated. Following the meeting the American Institute of Electrical Engineers will hold a smoker at its headquarters, to which the members of the Society are invited. An informal dinner (a la carte) will be served at 6:30 p.m

PERSONALS

John Kirk resigned recently as chief engineer of the power house of the Portsmouth Electric Ry., Portsmouth, N. H., to accept the position of chief engineer of the "Cow Pasture" pumping station of the main drainage system of the city of Boston, at Dorchester, Mass. He had been the chief engineer since the opening of the power plant in 1899.

NEW PUBLICATIONS

SHOP SKETCHING. By Joseph W. Woolley and Roy B. Meredith. Published by the McGraw-Hill Book Co., New York City, 1913. Cloth, 6x9 in., 102 pages; 122 illustrations. Price, $1.

This book is an excellent treatise on elementary mechanical drawing. It is not intended to make draftsmen, but it gives all the necessary principles for the shopmen and apprentices who need a clear knowledge of mechanical drawing in their everyday work. These are given in the most direct manner by problems requiring the student to construct other views from given drawings.

The book consists of seven chapters, every one of which is a little compendium for the purpose it serves. It is interesting to note that the authors have confined themselves to the most necessary drawing instruments: Pad, pencil, scale or rule, eraser, and pencil-compass, the reason being that only these would be available "on the job."

Chapter 1 gives all the principles of mechanical drawing, including drawing from objects.

Chapter 2 deals with screws and screw fastenings, while some useful problems are left for the student to solve.

Chapters 3 and 4 take up all the possible sections and views of a mechanical drawing and also deal with the assembly and methods of expressing detail, in a clear and comprehensive manner without burdening the student with the rules of descriptive geometry. This is one of the most valuable chapters of the book, and it should enable the student to learn to visualize an object from a drawing.

Chapter 5 gives all the possible types of gears and calculations for laying them out, while Chapters 6 and 7 explain in much detail isometric and freehand drawings. The examples of isometric drawing on isometric and on plain paper are very instructive as the objects are taken from practice. The chapter on freehand sketching deserves a somewhat more detailed treatment as would be expected from the title of the book.

⁂

Situation for Inspector of Mechanical and Electrical Engineering—The United States Civil Service Commission announces an open competitive examination for inspector of mechanical and electrical engineering on Jan. 21, 22 and 23 to fill a vacancy in this position, at $2000 a year, in the Office of the Supervising Architect of the Treasury. Subjects: Practical questions in mechanical and electrical engineering, drawing and design, and training and experience. The duties consist of inspecting and testing the mechanical and electrical equipments entering into the modern Government or office building. Applicants should have had practical experience in the design, construction and inspection of heating and ventilating apparatus, plumbing, water-supply and drainage, conduit and wiring work, elevators, vacuum-cleaning systems, and electric generating plants. They must be citizens of the United States, 20 years old or over, and should at once apply for Form 1312 to the United States Civil Service Commission, Washington, D. C.

⁂

Situation for License Inspector—The Civil Service Commission of Chicago, Ill., will hold an examination, Dec. 30, for the position of license inspector, Class H, Grade II, salary $1080-$1440. Subjects of Examination: Special subject, penmanship, arithmetic, experience, report. Duties: To inspect steam plants; to see that licensed engineers and water tenders are in charge; to report to the department daily, in writing, on conditions found in the plants visited; to notify the department regarding engineers or water tenders who have not had their licenses properly transferred, or whose licenses are not uptodate; to act as a witness in court against violators reported by him, and to assist in office work when required.

⁂

Situation for Hoisting Engineer—The Civil Service Commission of Chicago, Ill., will hold an examination Jan. 8, for the position of hoisting engineer, Class Ea, Grade II. Subjects of examination: Special subject, experience, arithmetic, report. Further information can be had by addressing the secretary of the Commission, R. A. Widdowson, Room 610, City Hall.

⁂

Tests for Welded Joints—In our issue of Aug. 12 and 26 we announced that the Zentralbüro, für Acetylen und autogene Metallearbitung, at Nürnberg, had offered a prize for the best method of proving the integrity of a welded joint. On Nov. 11 the contributions submitted were examined by a committee presided over by Herr Geh. Regierungsrat, Prof. Dr., Ing. Dr. F. Wüst, of Aachen. It was decided that none of the contestants had offered a complete solution of the problem, but that of the 26 suggestions received, five had possibilities. These will be tried out and developed under Professor Schlesinger at the Klg. technischen Hochschule, at Charlottenburg, and Professor Baumann, at the technischen Hochschule, at Stuttgart. It is hoped that one or the other of these proposed methods will offer a positive means of telling whether a welded joint is sound.

⁂

Big Creek Development Supplies Emergency Service—The first power from the Big Creek Development in California was transmitted a distance of 241 miles to Los Angeles a few weeks ago, says the "Philadelphia Ledger," to supply emergency service arising through a temporary shutdown of part of the Redondo plant. This hydro-electric development is notable chiefly because it employs, in transmission, the highest voltage used to date, namely, 150,000 volts.

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